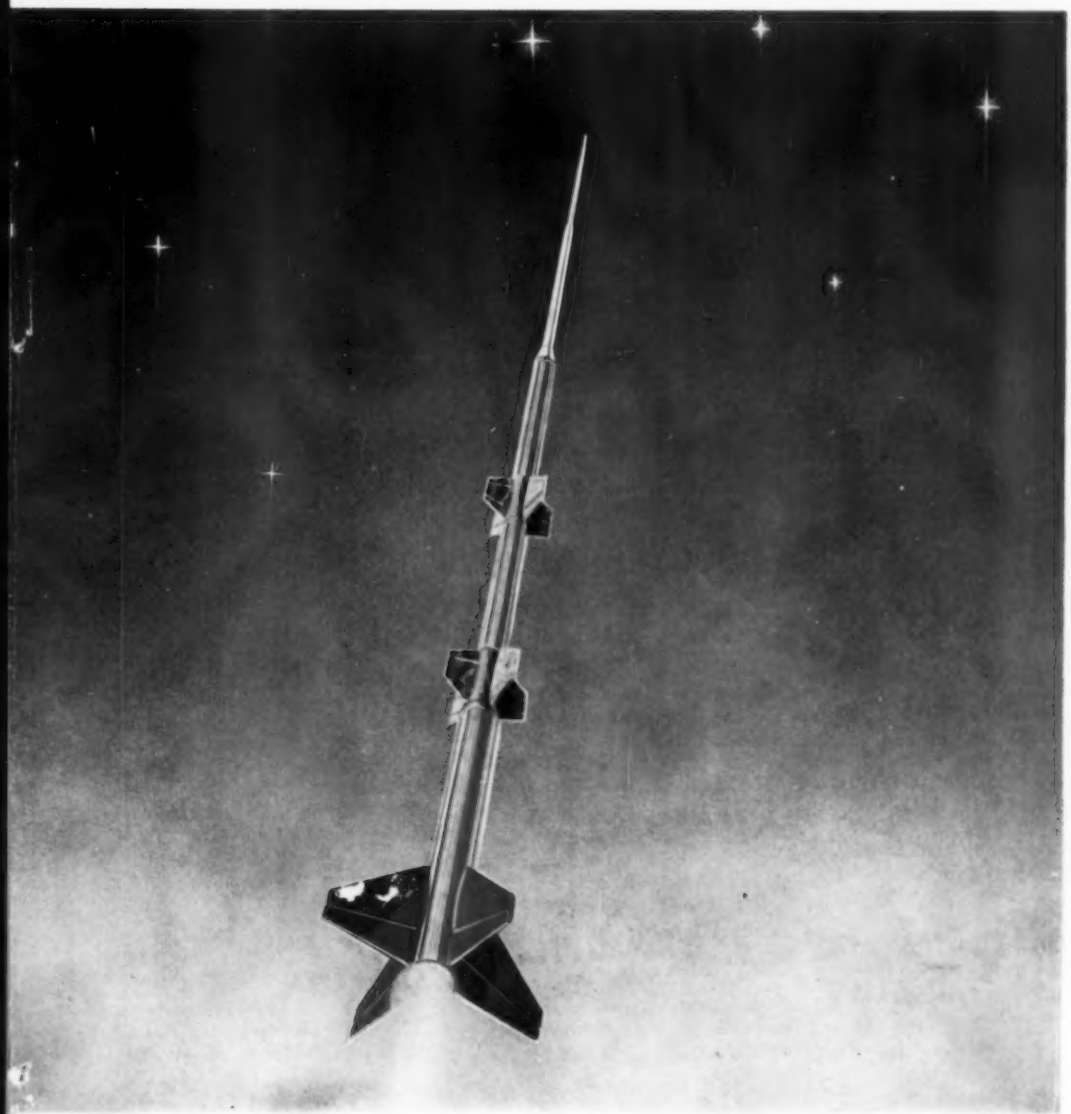
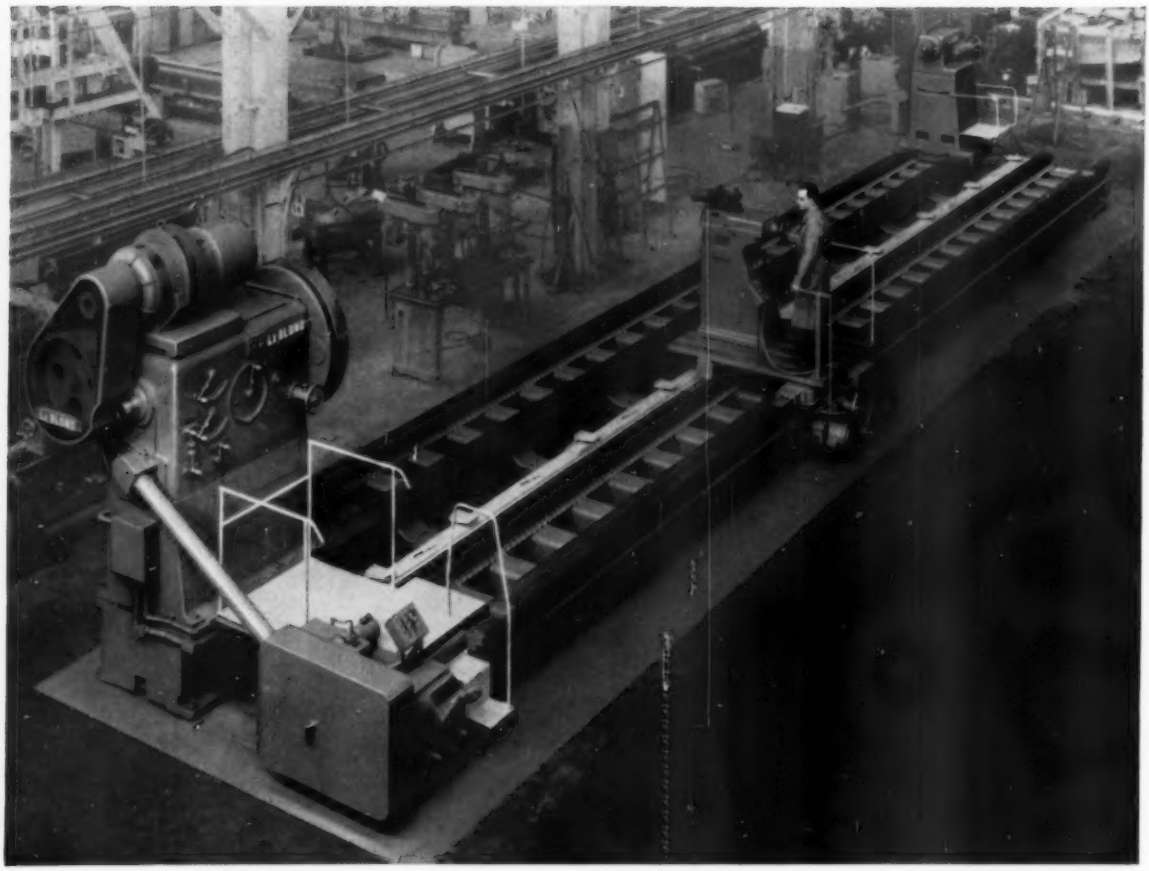
ORDNANCE

LAND · SEA · AIR · SPACE



Army Ordnance research rocket

NOVEMBER-DECEMBER 1959



First U.S. double-bed lathe... Le Blond's huge "Admiral"... assures spindle rigidity with Timken® bearings

IT'S a giant! . . . this lathe built by R. K. Le Blond Machine Tool Co. Named the "Admiral", it's the first U.S.-built double-bed lathe. And it weighs 75 tons, is 54 ft. 6 in. long, 120 in. wide. To maintain spindle rigidity under 50,000 lb. line load, Le Blond mounts it on Timken® tapered roller bearings. And for extra quality, the lathe ways are made of Timken 91140 steel. Le Blond uses Timken bearings to get:

1) *Special precision.* Timken bearings are made specifically for precision spindle applications.

2) *Extra load-carrying capacity.* Full-line contact between rollers and races gives Timken bearings extra capacity and their tapered design lets Timken bearings take *both* radial and thrust loads. They hold the spindle rigid.

3) *Extra toughness.* The bearing's heart—the steel—is nickel-rich. And to be sure it's the finest we make it ourselves . . . America's only bearing maker that does.

4) *Virtually eliminate friction.* Timken bearings are designed and precision-made to roll true.

For machines that perform better at lower cost, be sure the ones you buy or build are equipped with Timken tapered roller bearings. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*

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4. Pace setter in lower bearing costs

BETTER-NESS rolls on

TIMKEN®

First in bearings for 60 years

tapered roller bearings

ORDNANCE

LAND·SEA·AIR·SPACE

Forty Years of Leadership in American Armament Preparedness

VOL. XLIV NOVEMBER-DECEMBER 1959 NO. 237

The Cover.—*This is an artist's concept of the 5-stage vehicle being assembled by the University of Michigan for the Army Ordnance Ballistic Research Laboratories. It will be used to probe the ionosphere and is expected to reach an altitude of over 1,000 miles with an instrument payload.*

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ORDNANCE is published bimonthly by the American Ordnance Association, Mills Building, Washington 6, D. C. Second-class postage paid at Washington, D. C., and at additional mailing offices.

Subscription rate: Continental United States and possessions, $5.50 annually in advance; foreign, $7.00.

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Six weeks' notice before next publication date required for change of address.

FIREPOWER, formerly published separately by the American Ordnance Association, is combined with ORDNANCE magazine.

IN THIS ISSUE

Hon. Thomas S. Gates, Jr. . . . . . **Frontispiece**
Official photograph of the Deputy Secretary of Defense

Arms and the Budget 385
Our widespread military commitments demand larger appropriations

Guns in the Atomic Age . . . . . **Mark S. Watson** 386
Field artillery may be superior to missiles in precision and economy

Broken-backed Warfare . . . . . **Col. Virgil Ney** 391
Industry must be prepared to continue production after an attack

Maj. Alfred Mordecai . . . . . **Stanley L. Falk** 395
This early Ordnance officer applied scientific methods to arms making

Testing Nuclear Ordnance . . . . **William A. Gardner** 399
Desert laboratory subjects equipment to varied environmental changes

Logistics of Freedom . . . . . **Adm. John M. Will** 402
The Military Sea Transportation Service fulfills a vital role

Ordnance for the New Army 405
An account of the Association's 41st Annual Meeting at Aberdeen

Single-standard Problems . **Lieut. Col. Melvin M. Johnson, Jr.** 410
Many practical obstacles hinder attainment of this armament ideal

Our Defense Posture 412
Program of the A.O.A. Industrial Preparedness Meeting

The Mace Missile . . . . **Maj. Gen. Daniel W. Jenkins** 414
A versatile weapon with a self-contained navigational system

Modern Fuzes . . . . . **Robert L. Eichberg** 416
These amazing devices have varying degrees of built-in "intelligence"

Defense Highlights 419
Monthly review and outlook on national security

No Time for Half-way Armament . . . . **An Editorial** 421
We must have more than a showcase of samples in new weaponry

IN EVERY ISSUE

Atomic Energy 370
Association Affairs . . . 422
New Developments . . . 434
Space Armament . . . 451
Materials Progress . . . 458
Recent Patents 468
Rockets & Guided Missiles 474
Armament Electronics . . 479
Book Reviews 490
Index of Advertisements . 517

ARMAMENT TECHNOLOGY

Cermets for Ordnance . . . . . **John M. Woulbroun** 501
Ceramic-metal mixtures meet the needs of high-temperature conditions

Explosives Crystallization . . . **Dr. Walter C. McCrone** 506
Effective control of crystal growth improves explosives

Jewel Bearing Dilemma . . . . . **Robert Schwebel** 508
Increased demand has not yet led to increased production facilities

Weather to Order . **Fred Hermann and Seymour Sternbach** 512
Climatic facility at Frankford Arsenal provides simulated environments

He took the luck out of heads or tails

This AMF engineer had a delicate problem: to accomplish the separation of the expended stages of a multi-stage rocket. If separation occurs too soon, thrust in the nearly burned out stage may exceed the aerodynamic drag, the tail overtakes the head, and... boom. A million dollar collision and no insurance.

His solution: An acceleration switch that turns the burned out stage loose at the right split second ...a switch that makes rockets think for themselves.

His switch is compact. It is designed to work in any missile at any range with any payload. It is ingeniously simple in conception, design, and operation. A spring is attached to a free swinging hammer, the spring force acting to pull the hammer against the contact plate. At calibration the spring can be set to oppose any G from 1 to 100. When the missile is launched, the hammer is held back by the acceleration forces until the stage decays to the desired separation G. When the spring force overcomes the forces of acceleration, the hammer comes forward, strikes the contact plate, and the circuit required to make separation is closed automatically. No guesswork, no luck, no *collision.*

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Important news for owners of CEC's 5-114 recording oscillograph

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provides developed, dried, fully visible records almost instantly

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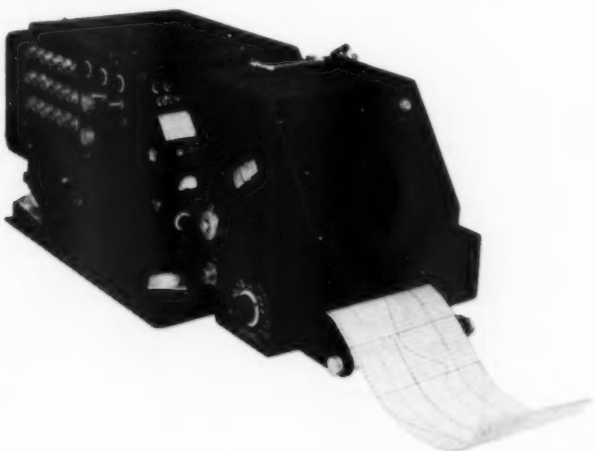
For complete details call your nearest CEC sales and service office, or write for Bulletin CEC 1500-X25.



Electro Mechanical Instrument Division CEC

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LITTLE RED RIDING HOOD • *so the story goes . . .*

was taking a basket of goodies to her grandmother's house. A basket of goodies or coals to Newcastle, some of us are always facing the problem of transporting things from place to place.

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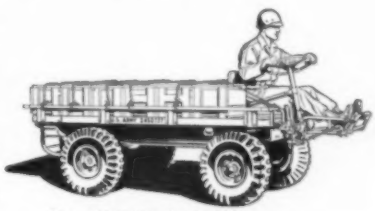

'Jeep' M-274 Mechanical Mule

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U.S. Army Signal Corps ground portable radar unit operated with two AiResearch electromechanical actuation systems.

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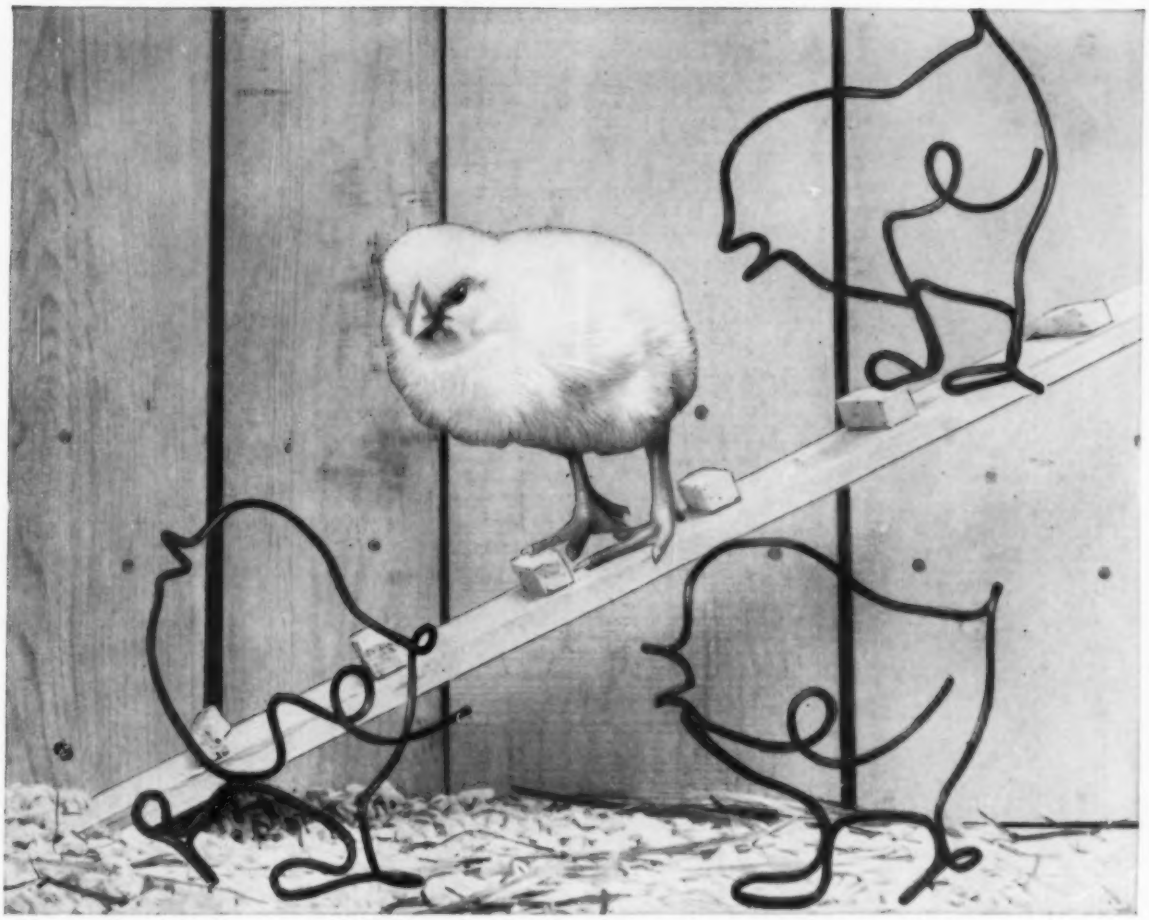

Bundy can mass-fabricate practically anything

Bundyweld®—the original double-walled steel tubing—is ideal for everything from simple bends to complex shapes

The old adage, "Don't count your chickens before they hatch," is a good one . . . but it rarely applies to Bundy. That's because, no matter how complex your tubing problem, you *can* count on Bundy for the perfect solution.

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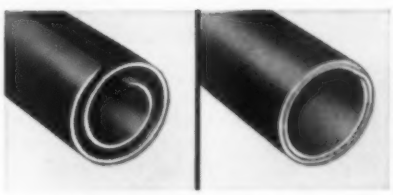

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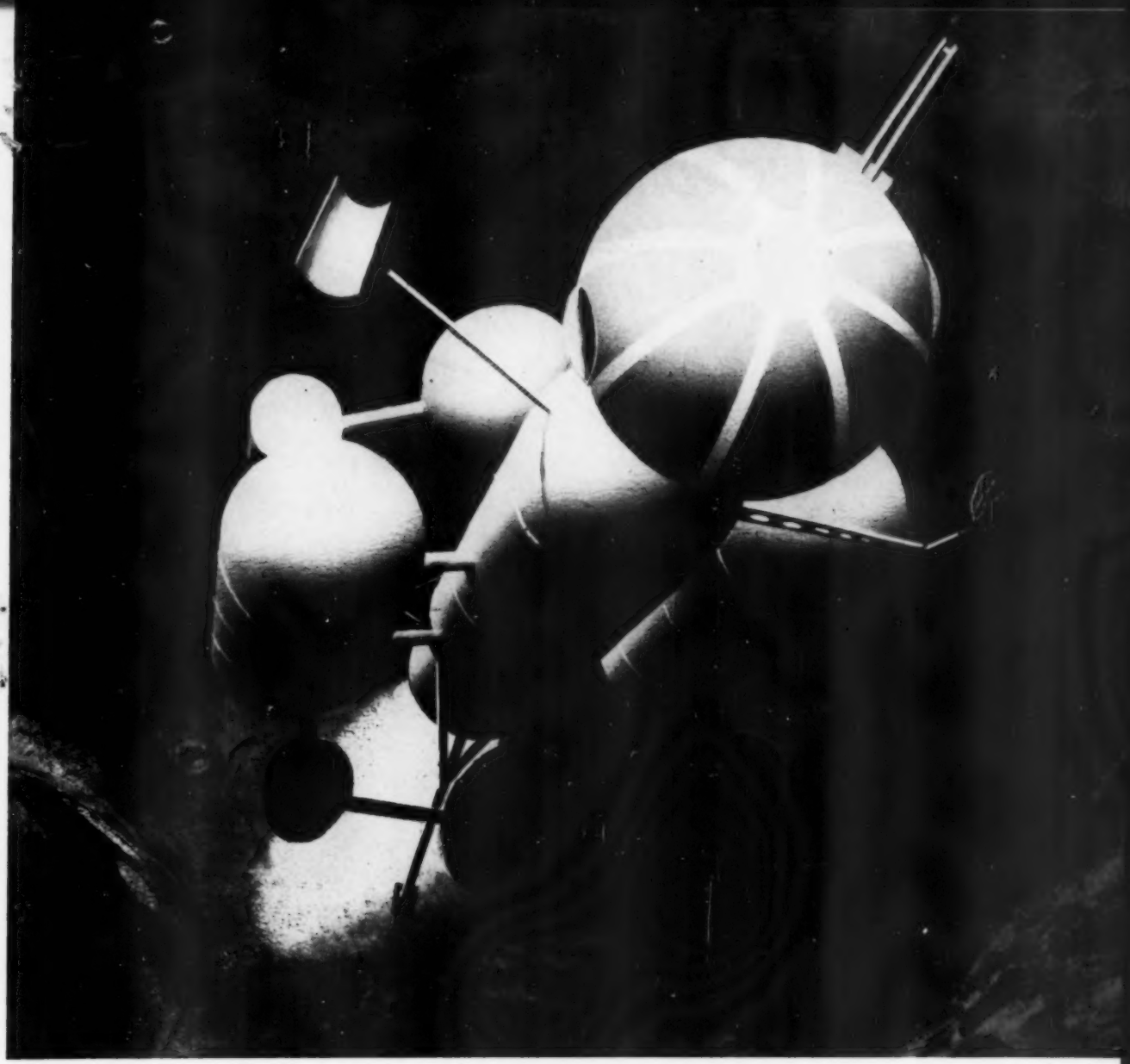
General Mills scientists are helping today to

The Mechanical Division of General Mills is contributing to man's knowledge of space through work in the vast field of geophysics. Important effort is directed toward increased knowledge of space phenomena vital to the future of space travel.

Our research activities cover broad areas in physics, chemistry, mechanics, electronics and mathematics. Some of the studies representative of these activities are: ions in vacuum, deuterium sputtering, dust erosion, magnetic materials, stress measurements, surface friction and phenomena, trajectory data and infrared surveillance.

In our engineering department, current projects include: airborne early warning systems, micro wave radar test equipment, antennas and pedestals, infrared and optics, inertial



man reaches the moon . . . illustration from a book written for General Mills by Willy Ley.

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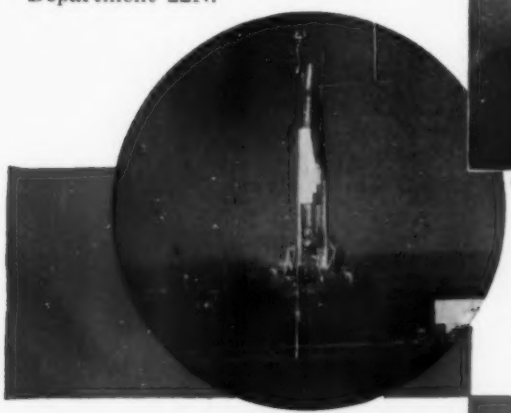
Here are two different Kollmorgen products designed for the missiles field. One is a remote viewing device, the other is used for acquisition and tracking. These are essentially optical instruments, but most Kollmorgen products also include electronic controls and components. Kollmorgen specializes in design and manufacture of a variety of highly precise instruments and systems for both industrial and defense viewing and inspection applications.

We have recently prepared a twenty-four page illustrated brochure which describes our facilities and primary fields of interest. For a copy, please write to Department 22N.



Official USAF photos

At Cape Canaveral, remote viewing of missile firing and static tests is accomplished with Kollmorgen bunker-type periscopes. Bunkerscopes have varying degrees of magnification, show images in true color and allow detailed observation of hazardous operations with no danger to personnel. The photograph at left was taken through a Bunkerscope at low power. For close-up observation and photography, the high power range brings the subject many times closer. Bunkerscopes are easy to operate, need no special care.

for missile tracking

Adapted from a basic Kollmorgen design, Missile Tracking Binoculars form an integral part of an acquisition and photography system which records the performance of tactical air-to-air missiles at China Lake Naval Ordnance Testing Station. These high-power, wide-field instruments enable an operator to spot and track a missile from before the time it is fired until it reaches its designated target.

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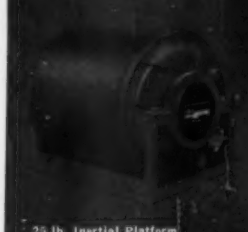

25 lb. Inertial Platform

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SURVEILLANCE DRONE SYSTEMS BY AEROJET

The Army's AN/USD-2 is today's most advanced drone system for gathering information on enemy battlefields. This high priority Army program is a major part of Aerojet's acquisition of the Rheem Defense and Technical Products Division at Downey, California. Under the cognizance of Aerojet's Aeronautical Division, the SD-2 project is receiving increased emphasis during its advanced system development stages.

Developed for the Army Signal Corps, the SD-2 is launched from a standard Army trailer and flown by remote control to survey enemy positions. Its sensory compartment accommodates photo transmission systems, infrared, radar or other new electronic devices that transmit or bring back data. Outstanding characteristics of the SD-2 are the stable flight platform, sophisticated navigational system and unique parachute recovery, which make it ideal for a variety of military assignments.

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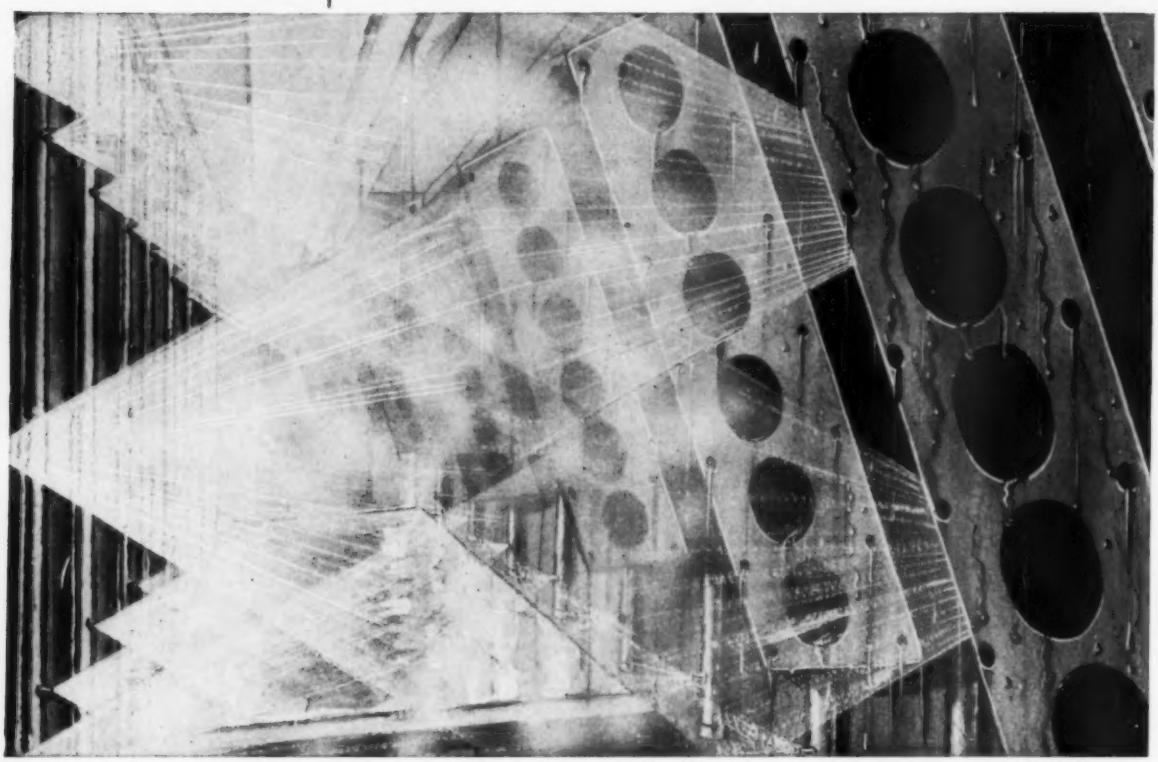

New Oakite 198 sprays off soils fast... protects in-process parts from rust

Users tell us that nothing equals Oakite 198 for cleaning parts in-process. Here's why they think so:

- *It clears off heaviest soils at temperatures up to 180°F, and light soils at room temperature.*
- *Metal chips wash away under its action.*
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Now largely used in automotive plants, Oakite 198 is proving its economy as well as its unique effectiveness in providing fast, smut-free cleaning plus rust protection. It works in single or multistage machines, at economical concentrations.

Oakite 198 is just one of a complete line of Oakite materials for machine cleaning. There are non-foaming solvent agents for heaviest duty cleaning, alkaline cleaners for removing moderate to light soils. When you ask Oakite you can be sure of getting a cleaning compound designed to give you best possible results, designed to reduce your "per unit" cost. You can be sure, too, of getting prompt, intelligent in-plant service from your local Oakite man.

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For example: Rocket Engine Cases • Missile Ground Support and Installation Equipment Artillery Shells • Radar Structural Members • Armor Plate • Armored Vehicles

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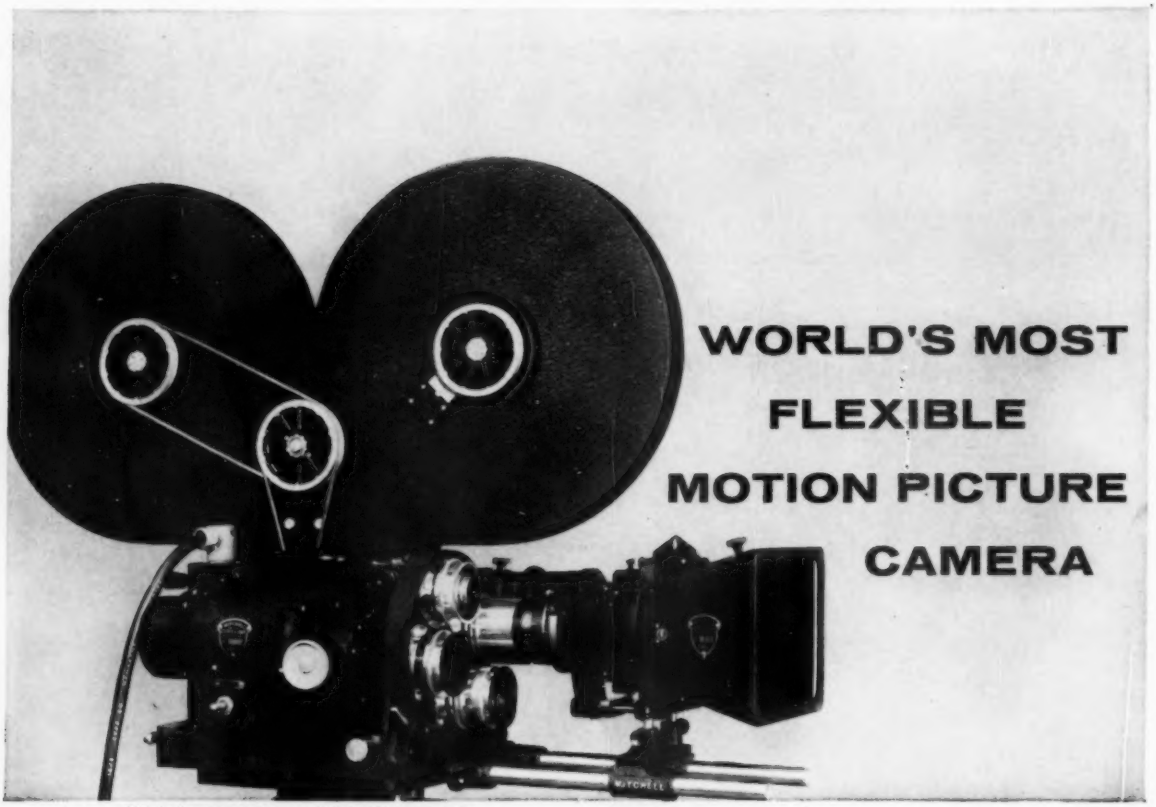


WORLD'S MOST FLEXIBLE MOTION PICTURE CAMERA

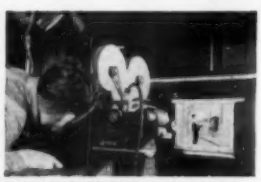
Mitchell camera shown with 1200′ magazine.

MITCHELL

No other motion picture camera is today used for such a broad range of exacting film making as is the Mitchell. The versatile speed of the camera, ranging from 1 to 128 frames per second, plus 14 exclusive features equip the Mitchell for an impressively broad range of cinematography. A single Mitchell can meet the requirements for finest quality TV commercials, feature productions, public relations, sales and training films, progress and report films, plus critical research and development data and record photography.

Mitchell cameras include: 35mm and 16mm cameras; 70mm 2¼ x 2¼ high speed cameras; and 70mm, 65mm and standard aperture cameras.

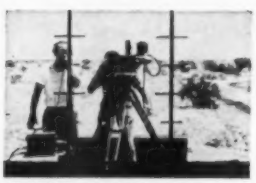
For information, write on your letterhead—please indicate which model camera your request concerns.



GENERAL ELECTRIC uses Mitchell for wide range of work, including slide films.

BUD WILKINSON PRODUCTIONS shoots its award-winning TV Sports Series with the Mitchell.

KEARNEY & TRECKER films first fully automated tape controlled combination machine tool with the firm's Mitchell camera.



LOCKHEED AIRCRAFT CORP., uses Mitchells continuously throughout plant, here records jet flight.

**85% of All Professional Motion Pictures Shown Throughout the World Are Filmed with Mitchell Cameras*

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1912 — First Automatic Flight — by **SPERRY**

Since Lawrence Sperry first flew automatically, thousands of Sperry automatic pilots have been standard equipment on a wide variety of aircraft – both military and commercial.

NOW...FROM SPERRY

The First Universal Automatic Pilot

REPLACES COSTLY CUSTOM SYSTEMS

A revolutionary 5-pound power unit is making aviation history. This "black box" is a universally adaptable servo system . . . and the heart of aviation's first Universal Automatic Pilot. The building block system will provide precise automatic control for all types of U. S. Army aircraft, including drones. Below the cost of custom-engineered flight control systems, it offers a variety of installation "packages" to achieve exactly the desired degree of flight automation.

DEVELOPED BY SIGNAL CORPS AND SPERRY

More than three years of study and development by the Avionics Division of the U.S. Army Signal Research and Development Laboratory, and Sperry, have gone into the design of the Universal system.

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By means of a small plug-in computer capsule, the system adapts itself to each aircraft type. A universal power unit is installed for each flight axis which it is desired to control: roll, pitch, yaw and throttle for fixed-wing aircraft, plus collective pitch and rotor rpm for helicopters.

UNIFIED COUPLING

An automatic navigation coupler gears the system to take its commands from such sources as VORTAC, ILS, radar altimeters, Doppler radar, and terrain-clearance radar – selected by the pilot. A special guide line coupler will permit helicopters to be flown "like kites" from the ground.

LOW WEIGHT PLUS EASE OF MAINTENANCE

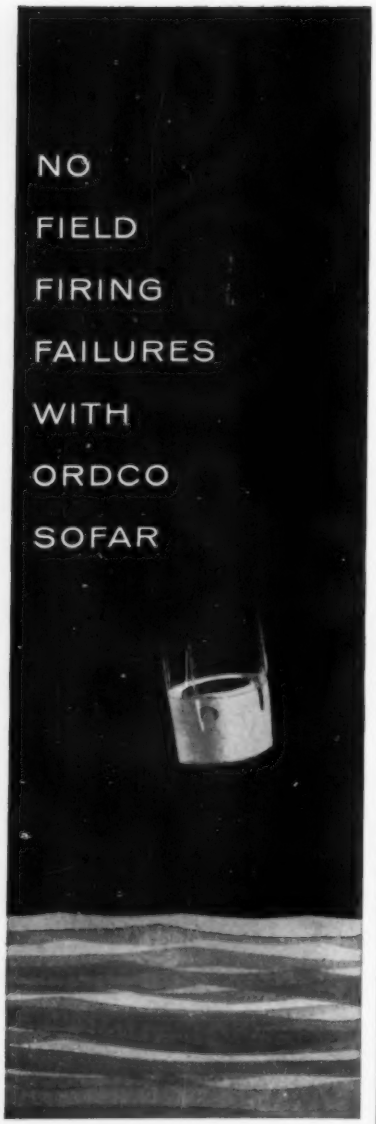
Weight factor varies with the degree of automation but a full fixed-wing system totals just 39 pounds; the complete five-axis helicopter system, only 54 pounds. Use of the unique "building blocks" simplifies maintenance and significantly reduces the amount of electronic harnessing and other cabling required.

By pioneering the development of the Universal Automatic Pilot, the Signal Corps and Sperry have made a major contribution to airborne technology, logistics, and the entire field of automatic control.

(1) Grumman YAO-1 Mohawk (2) Sikorsky H-34 Choctaw (3) Sikorsky H-37 Mojave (4) Beech L-23 Seminole (5) De Havilland YAC-1 Caribou (6) Vertol H-21 Shawnee

SPERRY

SPERRY PHOENIX COMPANY, DIVISION OF SPERRY RAND CORPORATION, PHOENIX, ARIZONA



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ORDCO Sound Fixing And Ranging devices—SOFAR—are engineered for no field firing failures. SOFAR units withstand water impact up to 70,000 Gs, arm at the correct depth and have fired with 100% reliability.

These SOFAR bombs, and related location-tracking equipment, have explosive charges ranging from .7 of a lb. to 10 lbs. Produced for the Armed Forces, they are the result of five years of ORDCO pioneering research and development.

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ATOMIC ENERGY

Plant Conversion

The Food Machinery and Chemical Corporation, New York, N. Y., recently was awarded a $13.5 million contract for the conversion of the former Dana Heavy Water Plant of the Atomic Energy Commission at Newport, Ind., into an Army Chemical Corps production facility. The contract calls for design, construction, and test operation of the facility for the production of chemical agents.

Upon completion, the Army intends to set up separate contracts for operation and maintenance of the plant. Studies indicate that it will cost $8 million less to convert the Dana plant than it would to build a complete new facility. Plant design at Newport, as at all major Chemical Corps installations, will incorporate the ultimate in safety devices and precautions.

Situated on land owned by the Department of Defense, the Dana plant was originally built by the AEC in 1950-1951, and went into operation in May 1952. It has been maintained on a stand-by basis in the period since June 1957 following the Commission's determination that the U. S. possesses an adequate stockpile of heavy water.

Thermal Breeder Reactors

The Atomic Energy Commission has initiated a long-range program to develop effective thermal breeder reactors which would make full use of the latent energy in thorium. Responsibility for the program, to be known as the thermal breeder reactor program, has been assigned to the Commission's Oak Ridge operations office.

Thorium is an element which, when bombarded with neutrons, is converted to fissionable uranium 233. It is more abundant in the earth than natural uranium. However, the amount of known reserves that can be exploited for commercial use is less than natural uranium.

A thermal breeder reactor is a reactor in which the nuclear chain reaction is sustained by neutrons moderated or slowed down to thermal (heat) energies and in which more fissionable material is produced than is consumed. In the initial loading of the thorium-uranium cycle, thorium is inserted in a reactor fueled with either uranium 235 or uranium 233, both fissionable materials.

The chain reaction is sustained by the uranium while the thorium is converted to new uranium 233. The uranium 233 produced is then available to replace the fissionable material used during the reactor's operation.

The new program has as its objective the development of a thermal breeder reactor capable of converting thorium to fissionable fuel material at a doubling time of not more than twenty-five years. The term "doubling time" refers to the time necessary for a reactor to produce enough excess fissionable material to start up a second similar reactor.

The new program also involves a reorientation of work on the fluid fuel reactor program previously conducted for the Commission by the Brookhaven National Laboratory, Upton, N. Y., and the Babcock & Wilcox Company, Lynchburg, Va., on the liquid metal fuel reactor (LMFR) concept and by the Oak Ridge National Laboratory, Oak Ridge, Tenn., on the aqueous homogeneous reactor (AHR) and molten salt reactor (MSR) concepts.

Much of the work on these projects has been directed toward the development of reactors of these concepts for the production of economic electric power. During fiscal year 1960, research and development on the AHR, MSR, and LMFR concepts, except as applicable to the new program, will be discontinued and a transition of financial support made to the new program.

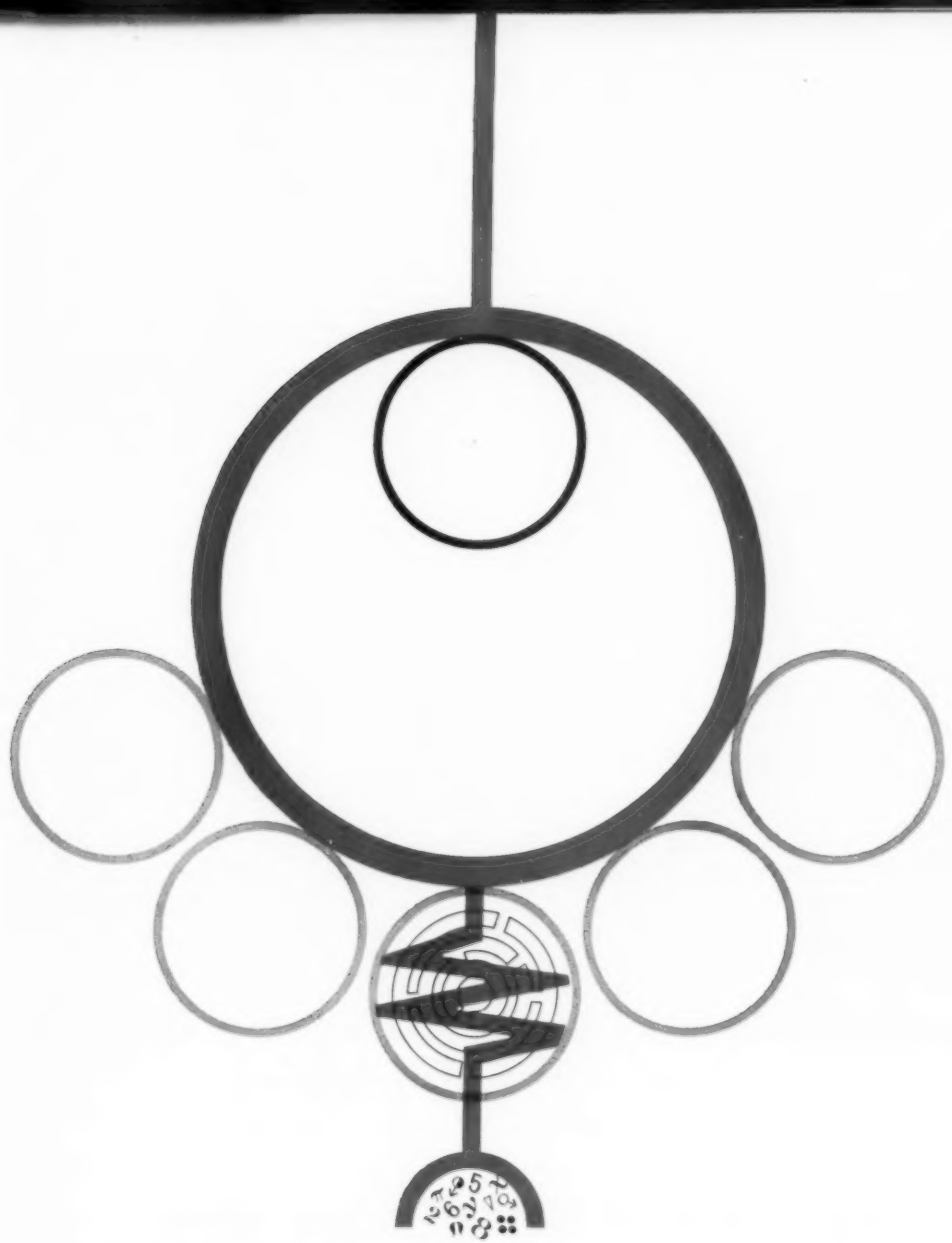
The Commission's decision to reorient the fluid fuel program and implement the thermal breeder reactor program was based on the results of a study by a special task force of scientists and engineers convened by the Commission in January 1959 to make a comparison of the reactor concepts included in the fluid fuel program.

As a result of task-force estimates of the power costs of large-scale fluid fuel reactors and on the cost and scope of research and development compared with that of other reactor concepts in advanced stages of development, the Commission concluded that there is little incentive for further development of fluid fuel reactors as an approach to the attainment of low-cost nuclear power in the near future.

Mobile Laboratories

Two mobile laboratory units have been presented to the International Atomic Energy Agency (IAEA) by the United

(*Continued on p. 374*)



COMPUTATION—PRIMED FOR THE TEAM PROGRAM

BURROUGHS CORPORATION IS UNIQUELY PREPARED TO CAPTAIN OR CREW THE CONTRACT TEAM PROGRAM. ITS MAJOR CONCERNS ARE COMPUTATION—AND COOPERATION. THE FORMER RANGING FROM BASIC RESEARCH AND SYSTEMS ENGINEERING THROUGH PRODUCTION TO FIELD SERVICE; THE LATTER DEMONSTRATED BY EFFECTIVE INTERFACING RELATIONSHIPS AND INTER-TEAM COMMUNICATION. WITH THE BENEFIT OF BOTH, THE TEAM APPROACH TO ANY SPACE AGE PROBLEM IS SMOOTHER, STRONGER, AND ABOVE ALL, SUCCESSFUL.

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The AISI 4340 steel in these gears gives you strength, toughness, and reliability. It's readily annealed, yet it can be machined at fairly high hardness levels. It welds easily with appropriate procedures and responds reliably to heat treatment.

Gears of 4340 Nickel alloy steel keep slabbing mills rolling . . . dependably

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United Engineering and Foundry Company reports, "4340 Nickel-alloyed steel mill gears are still on the job after three years' service."

You can expect maximum performance from 4340 through-hardening steel because of its excellent combination of strength and toughness when properly heat treated. Its high hardenability insures uniform properties in parts like gears which have different section sizes.

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For detailed discussion of TI Surveillance hardware, currently in production for the USAF and US Army Signal Corps — cleared personnel "with need to know" are urged to call or write: SERVICE ENGINEERING DEPT.

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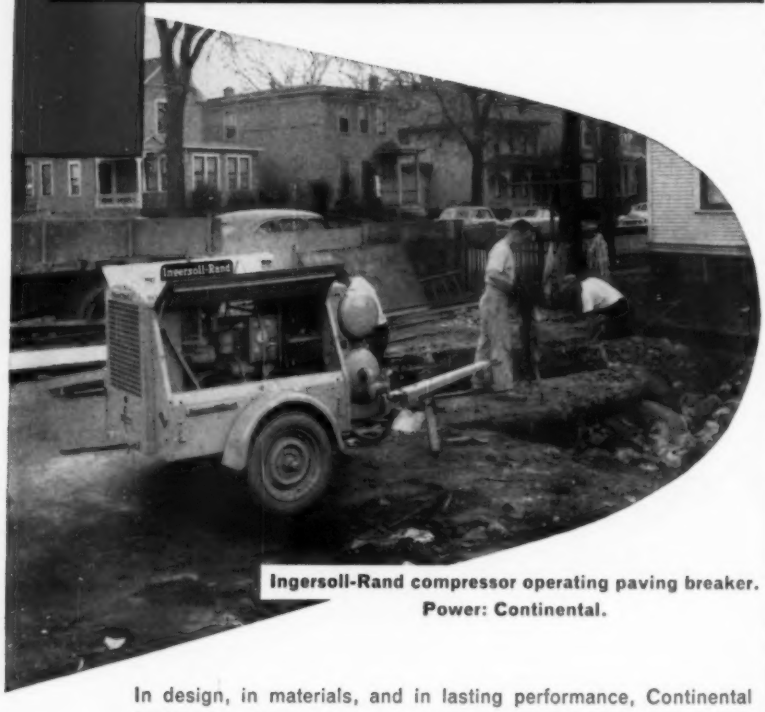

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Power: Continental.

In design, in materials, and in lasting performance, Continental Red Seal engines give you the benefit of 57 years' aggressive engineering. Traditional Red Seal ruggedness finds its natural reflection in rock-bottom upkeep costs. You find Continental-powered equipment on the job—wherever there's a job to be done—in excavating, ditching, concrete ripping, railway building and maintenance, and all phases of road construction. Every Continental Red Seal is not only built for the job, but backed by parts and service facilities the world over.

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Atomic Energy (Contd.)

States as part of the Atoms-for-Peace program proposed by President Eisenhower in a speech before the United Nations on December 8, 1953.

The laboratories will equip the IAEA to initiate for interested countries a program similar to the radioisotopes training courses offered by the Oak Ridge Institute of Nuclear Studies (ORINS) at Oak Ridge, Tenn., thus enabling foreign universities and research institutions to give such instruction.

The mobile units were designed by ORINS at the request of the Commission, and the Lyncoach Company, Inc., Oneonta, N. Y., did the construction work.

Each self-contained, bus-type unit is about 35 feet in length and carries its own 10-kilowatt generator to provide power for the training equipment. It will accommodate six students at each session. The total cost of each laboratory, including the equipment, is about $56,000 which will be paid from Mutual Security funds made available to the Commission by the U. S. International Cooperation Administration.

U. S.-Euratom Research

The U. S.-Euratom Joint Research and Development Board recently announced the award of contracts totaling approximately $315,000 to three United States and European research institutions and industrial firms. The awards represent the first contracts to be negotiated under the U. S.-Euratom Joint Research and Development Program.

The firms and the nature of their proposals are: American Standard Corporation (U. S.)—clad ceramic plate fuel elements by spray-coating techniques; Battelle Memorial Institute (U. S.)—boiling heat transfer and void distribution on studies with water coolants; Compagnie Industrielle Des Ceramiques Electroniques (France)—study of the extrusion of uranium oxide.

The U. S.-Euratom Joint Research and Development Board is continuing its review of the over 200 proposals received from United States and European firms in response to an invitation issued last December to industry, research groups, and educational institutions to participate in the joint program.

Commercial Reactor Fuels

Vitro Engineering Company, a division of Vitro Corporation of America, has been awarded a $4.3 million contract by the Atomic Energy Commission to design and engineer a new facility at the Hanford Works for the processing of commercial power reactor fuels.

This facility, planned for operation in early 1961, will reprocess from 50 to 150 tons per year of fuel element materials

(up to 5 per cent U-235). It will be capable of handling fuel elements of all designs and shapes including oxide and alloy cores clad with aluminum, zirconium, and stainless steel. Elements will be received in shielded casks, stored in a water environment, dismantled mechanically, and chemically treated in preparation for processing by solvent extraction in existing Redox facilities. These Redox facilities were originally designed by Vitro for the AEC in 1949.

A new receiving building will be used for the transfer, cleaning, and handling of fuel element casks delivered by rail cars. New facilities for fuel-element storage, mechanical preparation, dissolution, and metal-solution storage will be housed in existing buildings.

Undissolved fuel elements will be stored in redesigned tanks in existing heavily shielded remote-type cells. Element fittings will be removed mechanically and the elements dissolved in new equipment in existing cells. Metal solutions will be clarified by centrifugation before interim storage in relocated vessels.

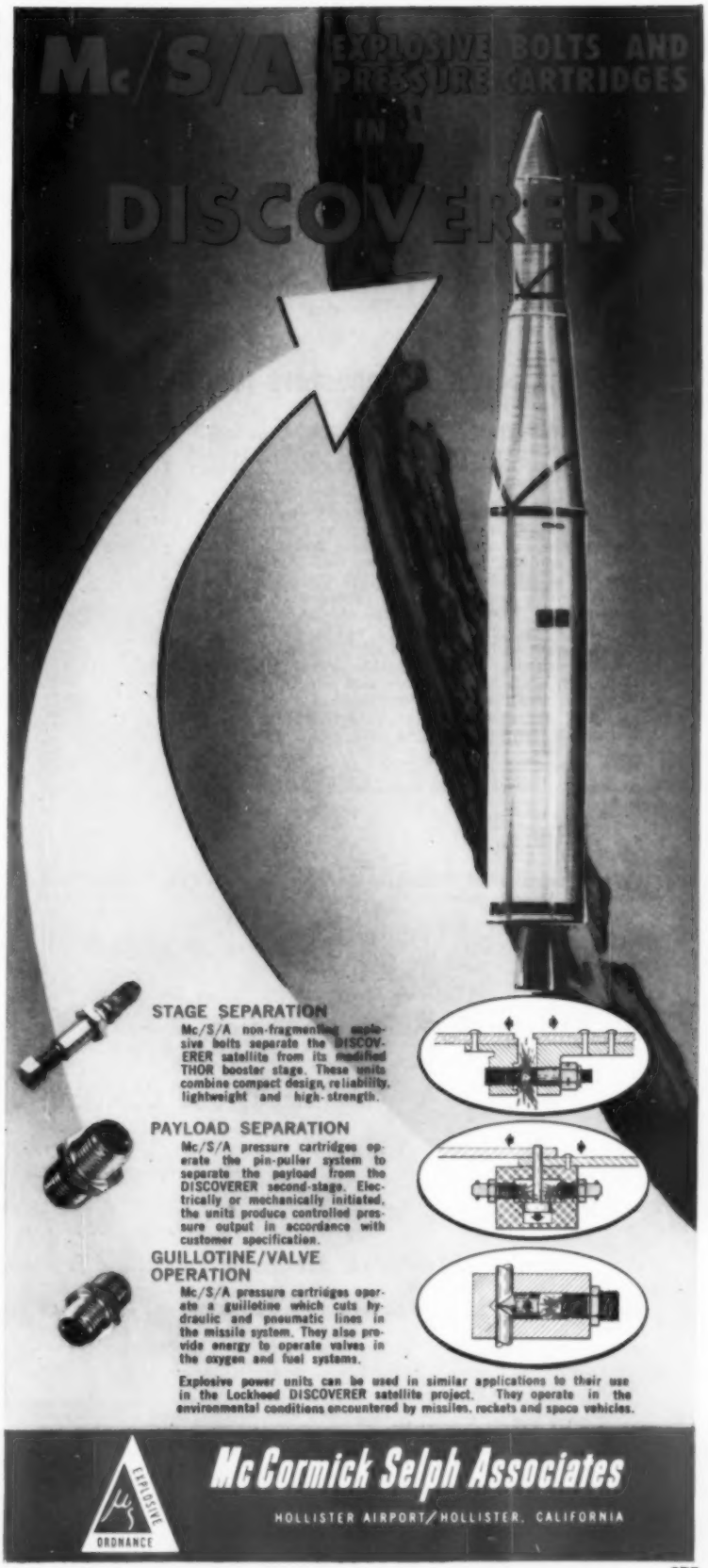
Tanker Reactor Study

The Atomic Energy Commission has awarded a contract to Combustion Engineering, Inc., Windsor, Conn., for a design and engineering study of a prototype pressurized water reactor to propel a tanker. Estimated cost of the study, which is to be completed by the end of the year, is $150,000. The study is being conducted with the cooperation of the Maritime Administration, U. S. Department of Commerce.

The Combustion Engineering study is part of an AEC project to investigate the suitability of various reactor types to serve as the nuclear power plant for a 45,000-deadweight-ton tanker capable of being built and ready for operation by 1964. The ship would have a speed of 18.5 knots at a normal shaft horsepower of 27,300; maximum shaft horsepower would be 30,000.

Reactor types being studied by the Commission for possible nuclear tanker applications include: direct cycle, natural circulation, boiling water; indirect cycle, boiling water; natural circulation, pressurized water; and organic moderated and cooled. The design and engineering studies for the nuclear tanker were authorized by Public Law 86-50.

The Combustion Engineering study will include an appraisal of present pressurized water reactor technology for maritime use, reflecting latest proven advances and pointing to future improvements. Special emphasis will be placed on the criteria of simplicity of design, compactness, self-regulation, and other features which would lead toward lower costs.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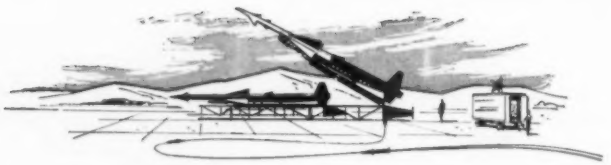
DISCOVERER
STAGE SEPARATION
Mc/S/A non-fragmenting explosive bolts separate the DISCOVERER satellite from its modified THOR booster stage. These units combine compact design, reliability, lightweight and high-strength.
PAYLOAD SEPARATION
Mc/S/A pressure cartridges operate the pin-puller system to separate the payload from the DISCOVERER second-stage. Electrically or mechanically initiated, the units produce controlled pressure output in accordance with customer specification.
GUILLOTINE/VALVE OPERATION
Mc/S/A pressure cartridges operate a guillotine which cuts hydraulic and pneumatic lines in the missile system. They also provide energy to operate valves in the oxygen and fuel systems.
Explosive power units can be used in similar applications to their use in the Lockheed DISCOVERER satellite project. They operate in the environmental conditions encountered by missiles, rockets and space vehicles.
EXPLOSIVE ORDNANCE
McCormick Selph Associates
HOLLISTER AIRPORT/HOLLISTER, CALIFORNIA



Why it pays you to specify

Bendix QWL Electrical Connectors for use with Multi-conductor Cable

For use with multi-conductor cable on missile launching, ground radar, and other equipment, the Bendix* QWL Electrical Connector meets the highest standards of design and performance.

A heavy-duty waterproof power and control connector, the QWL Series provides outstanding features: • The strength of machined bar stock aluminum with shock resistance and pressurization of resilient inserts. • The fast mating and disconnecting of a modified double stub thread. • The resistance to loosening under vibration provided by special tapered cross-section thread design. (Easily hand cleaned when contaminated with mud or sand.) • The outstanding resistance to corrosion and abrasion of an aluminum surface with the case hardening effect of Alumilite 225 anodic finish. • The firm anchoring of cable and effective waterproofing provided by the cable-compressing gland used within the cable accessory. • The watertight connector assembly assured by neoprene sealing gaskets. • The additional cable locking produced by a cable accessory designed to accommodate a Kellems stainless steel wire strain relief grip. • Prevention of inadvertent loosening insured by a left-hand accessory thread. • The high current capacity and low voltage drop of high-grade copper alloy contacts. Contact sizes 16 and 12 are closed entry design.

These are a few of the reasons it will pay you to specify the Bendix QWL electrical connector for the job that requires exceptional performance over long periods of time. *TRADEMARK

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Aeronca produces the precision parabolic radar reflectors as a D-T-P* "envelope" project, on a subcontract basis. Highly specialized skills and facilities are required to meet their stringent specifications.

A pioneer in honeycomb sandwich fabrications, Aeronca has the versatile, integrated facilities necessary to supply weapon system envelopes *efficiently, economically and on-schedule.*

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*Fabricated to curvature tolerances of ±.005", these precision honeycomb structures illustrate Aeronca's coordinated Design-Tool-Produce capability.

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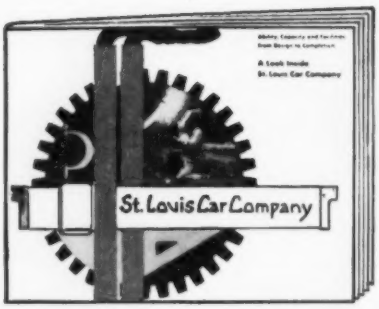

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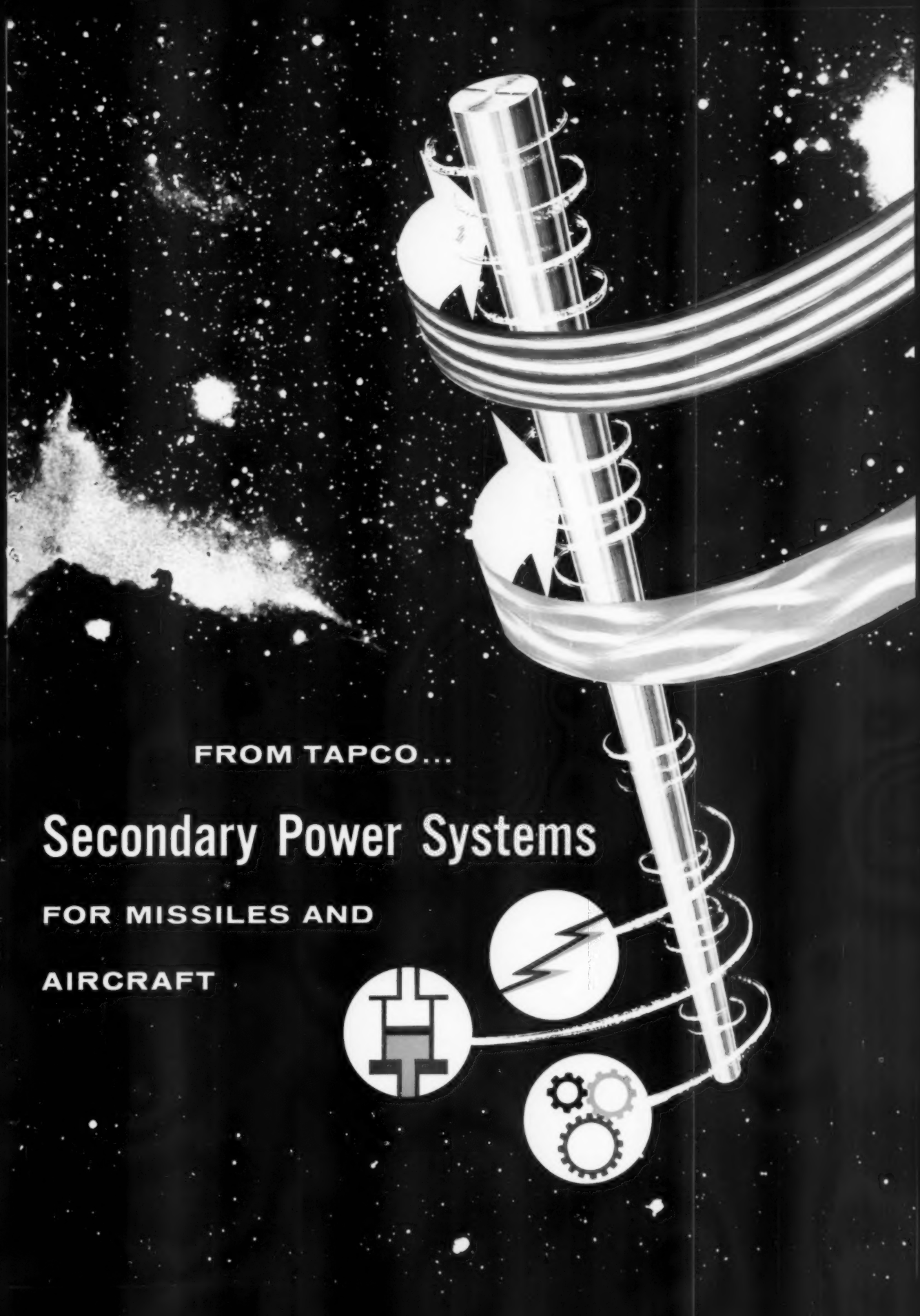
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FOR MISSILES AND
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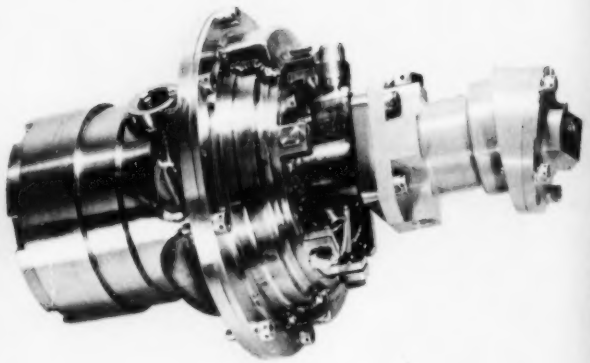
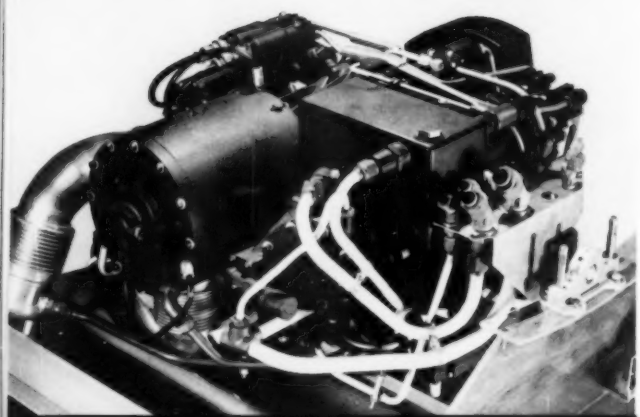
Secondary Power Systems using any energy source for any power output



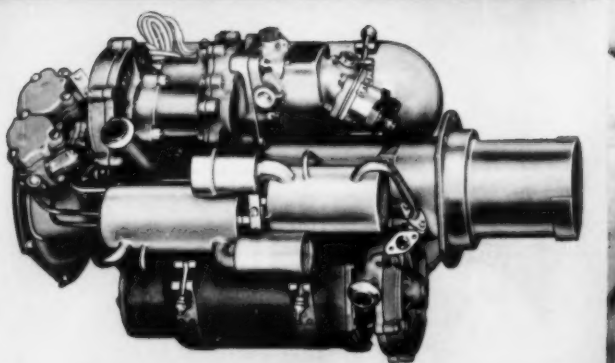
New TAPCO-developed UNIPUMP is a solid-fuel, self-regulating, single-shaft turbo-hydraulic supply. Capacities from 1 to 5 gpm at 3000 psi for durations up to 3 minutes.

Here you see a few of the secondary power systems developed and built by TAPCO for leading missile and aircraft manufacturers. These systems provide power for flight control and generate electrical energy with precisely-controlled frequencies as low as ±.001%.

Some TAPCO secondary power systems operate in high-temperature ambients. Others operate in the cryogenic range. Our half-century of experience in producing precision components to function reliably in abnormal ambients is especially important in



This TAPCO Auxiliary Power Unit, driven by a 4-stage solid-fueled turbine, produces 70 HP to generate 40 kva. of electricity and to drive a hydraulic pump for actuating controls.



Liquid fuel self-contained electrical and hydraulic power supply designed and developed by TAPCO. Solid fuel versions of these auxiliary power supply units are being used in Terrier missiles.

MINIAPS, a new TAPCO-developed solid-fuel miniature turbo generator, provides up to 200 watts of power. This multiple output concept supplies precise voltages and frequencies, in both AC and DC current for missile, fuzing and telemetering applications.

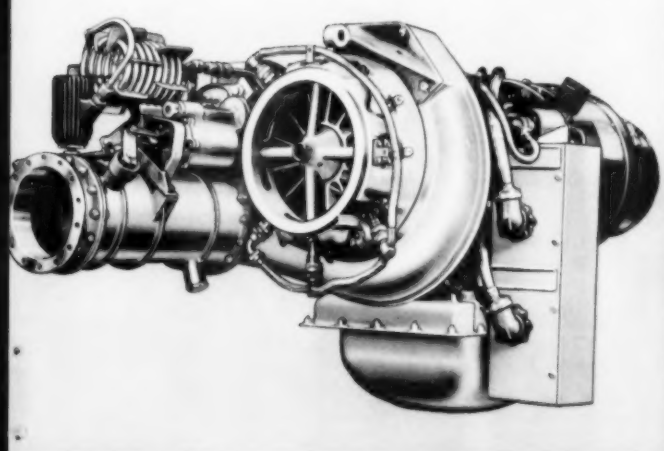
Auxiliary power unit designed by TAPCO to provide all electrical and actuation power for the advanced Bomarc missile. This is a completely self-contained package system which requires only a start signal to provide power for the missile during flight. It meets unusually difficult environmental conditions.

present-day and future applications. Also, our experience with metals and materials to resist the effects of corrosive liquids and gases is vital in producing turbines and power system components that are in contact with unusual combustion conditions resulting from liquid and solid propellent gas generators.

Some secondary power applications more economically use bleed or ram air as an energy source. TAPCO's broad background in the development of air turbines is valuable in applications of this type.

Years of experience in developing all types of pneumatic, electronic and mechanical controls is still another part of TAPCO's secondary power system capability. This includes rotating electrical machinery and electronic and electrical speed controls with transistorized components.

Advanced research is now underway at TAPCO to determine the secondary power systems of the future. This activity includes the investigation of such new energy sources as fuel cells, solar power and nuclear power.



Air-driven turbine and 60-kva alternator with TAPCO-designed controls that hold 400-cycle current to ±¼% stability in compounded operation.

TRW

TAPCO GROUP

Thompson Ramo Wooldridge Inc.

CLEVELAND 17, OHIO

DESIGNERS AND MANUFACTURERS OF SYSTEMS, SUBSYSTEMS AND COMPONENTS FOR THE AIRCRAFT, MISSILE, ORDNANCE, ELECTRONIC, AND NUCLEAR INDUSTRIES

In the TAPCO main research and test center shown here, all types of operating conditions can be simulated... high altitudes, elevated and cryogenic temperatures, high-speed rotation, hot-liquid and solid-fuel feeds, and multiple-G. Twelve other TAPCO research and test labs throughout the country augment this laboratory.

AT TAPCO...

Capabilities and Facilities to develop any Secondary Power System

For designing and developing secondary power systems for new applications, the TAPCO Group includes stress analysts, ceramicists and metallurgists, combustion engineers, computer programmers, and a score of other talents. A new project or idea can be staffed promptly with experts from the 1250-man TAPCO engineering group.

Available to these people are complete research, development, and test facilities, with equipment ranging from a 240-circuit, 80-channel analog computer to a high-altitude environmental test chamber.

In addition, when very unusual projects require it, the research people and facilities from the TRW staff and the 11 other TRW divisions can be called on.

More than 3-million square feet of TAPCO manufacturing facilities, equipped with every type of modern precision machine tool, are available to deliver your secondary power system on-schedule.

Three TAPCO testing facilities can test any secondary power system under simulated or actual operating conditions. This assures you of ready-to-go units proved to meet your requirements.

Let us work with you and your staff on your next requirement for a secondary power system of any type. Write to:

Complete facilities and manpower are available in the TAPCO Group for simulation, certification and pre-delivery testing of equipment built by TAPCO.

TAPCO's 1100-acre Roanoke Test Facility can run tests involving high-G, very-high temperatures, supersonic sound, high-amplitude vibration, high-radiation, shock, and high- altitude conditions in any combination. Shown below are some of the environmental test buildings, with Rucker Centrifuge pit to handle sustained acceleration from 0 to 60 G's and package sizes up to 600 lbs.

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AMERICAN ORDNANCE ASSOCIATION

Founded 1919

A patriotic, educational, scientific, nonpolitical, and nonprofit-making organization of American citizens dedicated to scientific and industrial preparedness for the common defense

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HON. THOMAS S. GATES, JR.

Deputy Secretary of Defense

Arms and the Budget

Our widespread military commitments demand balanced appropriations

THE Department of Defense in its role as the management of the Nation's most massive enterprise is faced with another period of unusually grave decision.

Defense leaders must not only carve up a budget fixed by economic instead of strategic considerations, but they must ensure that the United States does not drop its guard in the face of ill-conceived pressures brought on by recent Communist blandishments.

Thomas S. Gates, Jr., appointed Deputy Defense Secretary upon the untimely death of Donald A. Quarles, has a background of over six years of invaluable experience within the pentagonal maze. As Under Secretary and then Secretary of the Navy, he was concerned more with the broad aspects of sea power as part of the Nation's defense than with the Navy as an isolated service in our armed forces.

This administrative background in government and his knowledge of the inner workings of industry will enable Mr. Gates to take over a large share of the burdens of Secretary of Defense McElroy.

IN the inner sanctum of high-level decisions on budget distribution, the Secretary of Defense and his Deputy are being bombarded with pleadings. Each military and civilian leader will have irrefutable requirements upon which the life of the Nation may depend—but in front of them is the stark figure of about $41 billion. At this economic stone wall they must stop because bemused economists advise that the Nation, already burdened by billions of dollars of agricultural surpluses, would crumble under a heavier financial load.

Hon. Thomas S. Gates, Jr., the Deputy Secretary of Defense, was born in Germantown, Pa., and has been a lifelong resident of the Philadelphia area. He was graduated from the University of Pennsylvania in 1928 and joined the firm of Drexel & Company, investment bankers, becoming a partner in 1940.

Mr. Gates was commissioned in the Naval Reserve early in World War II and served on active duty throughout the war. His first assignment was the organization of the Naval Air Intelligence Center, Commander in Chief, Atlantic Fleet. He served in the carrier MONTEREY throughout 1943 and then reported to the staff of Rear Adm. Calvin T. Durgin who commanded our carriers in the invasion of southern France.

Mr. Gates returned to the Pacific where he fought the remainder of the war, taking part in operations in the Philippines, Iwo Jima, and Okinawa. For his war service he twice was awarded the Bronze Star and now holds a commission as captain, U.S.N.R., on the retired list.

Mr. Gates was appointed Under Secretary of the Navy by President Eisenhower and assumed that office in October 1953. On April 1, 1957, he succeeded the Hon. Charles S. Thomas as Secretary of the Navy. On February 10, 1959, President Eisenhower accepted Mr. Gates' resignation as Secretary of the Navy. Subsequently, on the death of the then Deputy Secretary of Defense, Donald A. Quarles, Mr. Gates was nominated to the position and assumed office on June 8, 1959.

Behind closed doors the proponents of strong limited-war capabilities battle those for all-out-war deterrents.

We need more trained fighting men, but missiles are frighteningly expensive to develop and produce. The armed forces we have are not adequately equipped with modern arms, but that expense must be balanced against more funds to reach out into space.

Maintenance, upkeep, storage, and training operations cannot be neglected; pay and perquisites must attract the best men—but the stone wall must not be cracked. It is a task of many complexities.

THE calculated risk is no longer on a profit-and-loss basis—it may affect thousands of lives rather than livelihood, even the life of the Nation. Politics assume a much broader aspect when both the dedicated legislator who seeks the best for his country and the one who seems interested only in local benefits must be convinced of defense needs. International relations can explode or swing like a pendulum to the embarrassment of defense planners.

It is in the latter imponderable area that the Defense Secretary, his Deputy, and all his advisers may be faced with the need for extreme toughness of mind. It is foreseen that there will be many pressures to reduce our strength in the face of talk about relaxing international tensions before such talk has been substantiated and proved realistic by visible deeds.

Mr. Gates, through his wartime service and his years in top Pentagon circles, has worked closely with the uniformed leaders and has their confidence and respect. He is familiar with Defense Department operations since, as chairman of the Navy Department Reorganization Committee in 1953, he made a study that included the Office of the Secretary of Defense in order to ensure maximum cooperation by the Navy Department.

In all respects Secretary Gates has splendid qualifications for his new office, and the Association welcomes him and pledges its full support.

Guns in the Atomic Age

(*Air Force photo*)

Mark S. Watson

THE celerity with which antiaircraft artillery has been replaced in a few short years, on land and sea alike, by surface-to-air missiles has undoubtedly encouraged a public belief that a similar fate for all artillery is just around the corner. Indeed one occasionally reads expressions of that belief, coming from people who should know better.

The missile now is supreme in surface-to-air missions for just one reason —the aerial target's behavior today is totally unlike that for which artillery was designed. The aerial target of 1959 flies very much faster and very much higher than did that of 1939-1945.

Incidentally some 600 artillery shells were expended for every airplane brought down in World War II, and it took no keen insight to realize in 1945 that for shooting down the newer planes then on the drawing board even the best antiaircraft guns would be about as effective as the bow and arrow.

Mr. Watson is a well-known military analyst and holder of the 1945 Pulitzer Prize for international correspondence. He is military correspondent on the staff of the Baltimore Sun.

Hence the understandable rush to the surface-to-air missile, and the continued rush to make it better, swifter, higher-reaching, carrying a far more destructive warhead, and possessing an in-built intelligence to which the antiaircraft artillery shell never aspired.

But the problems of surface-to-surface fire have undergone no such enormous alterations. To cope with them there is as yet no universal need for replacing tube artillery with missile or rocket fire. Rather, artillerymen and ordnancemen are united in the belief that for the fundamental missions of the combat division, whether in nuclear or nonnuclear warfare, the gun tube is far superior to the missile in precision as well as economy.

In surface-to-surface activities the missile and the rocket serve a very large purpose, but only for supplementary missions. In this area they do not replace the gun and will not do so during the predictable future, in the judgment of respected experts both in ordnance and in operations.

IT is necessary to bear in mind the distinction between the requirements of divisional firepower and those of corps or army units. The division is concerned almost wholly with its own immediate needs. The corps artillery is counted upon for reenforcement fire at need but, like that of the field army, it is more largely occupied with counterbattery and destruction missions. In those latter roles it must certainly be ex-

pected to make increasing use of missiles, particularly in nuclear warfare where their massive firepower justifies their cost and largely overcomes their present lack of precision.

But in the purely reenforcement fire from the corps, as in the division's own fire, it is interesting to learn, the authorities referred to are united in favoring the gun tube. The extent of that favor is convincingly shown in the newly revised tables of organization and equipment for the pentomic division, where—even in our so-called "missile age"—the new battle group will have a battalion of direct-support artillery instead of a battery and where the division's total of 155-mm. howitzers is being increased from twelve to thirty of these powerful weapons.

THIS is one of the most notable alterations in the original pattern for the pentomic division, and a most timely one, in that it has come while the National Guard and Army Reserve divisions are in the process of change-over from triangular to pentomic form, so that there will be no need in their cases for a double change of tables of organization and equipment.

Unfortunately, the divisions probably will not get the hoped-for self-propelled guns in scheduled number, simply because there are not enough of them either in stock or on order. This aspect of the situation will be touched upon later.

For its appropriate missions, today's long-range missile with atomic warhead is economical, not because of its accuracy, in which it cannot compare with the gun, but because of its long reach and because it does not have to hit the target with any high degree of precision to achieve destruction.

The division commander, as distinguished from the field-army commander, is not greatly interested in the very long reach, but he is very much concerned with precision of fire. A warhead which hits only somewhere near the enemy target and spreads its lethality for miles around is just what the division commander can do without, for the bulk of his fire must be so directed as not to endanger his own infantry's advance elements.

It is important for him, in antitank fire for example, to be able to knock out an enemy tank which is hurting his own infantry. But the tank usually is too close to permit the obliterating effect of a nuclear missile, which could hurt the infantry more than the tank has been hurting them. And yet a missile with a nonnuclear warhead can have very real trouble in hitting an enemy tank effectively at 2,000 yards, so small is the vulnerable spot of a tank and so narrow the angle of fire that can reach it.

True, the new Lacrosse missile, with its ocular guidance, has very great promise of high precision, as does the SS-10 at close range, but it is necessary to remember that an enemy's smoke-producing equipment can make trouble for ocular guidance. Electronic fire-control devices add complexities and high costs and call for retention of skilled and trained maintenance experts on the battlefield.

On the other hand, it must be pointed out that new antitank artillery has been making some phenomenal records for accuracy and lethality. The advances in the relatively new technologies of missilery are still so swift that long-range predictions are risky, but such future advances as now can be discerned have not discouraged today's confidence that the gun tube—in its newer forms, with its newer auxiliaries, and with its newer ammunition—will provide the main support reliance of the division for a long time to come, perhaps twenty years, in the horseback opinion of a respected expert in this area.

HENCE the current revision of the tables of organization and equipment for the pentomic division. When that basic combat element of the Army was being devised, the accepted judgment, based upon World War II experience and speculation about atomic war-

The 155-mm. howitzer M44 is a self-propelled weapon capable of supporting an infantry attack over rough terrain (Army photo).

The 155-mm. howitzer M1 must be towed by a prime mover, but it gave valuable service in the Korean campaign (Army photo).

Lighter than the standard model, the 8-inch howitzer T236 is designed for air transportability (Army photo).

The standard 8-inch howitzer M55 is a full-tracked, self-propelled weapon with armored crew space (Army photo).

fare, was that, in the interest of field mobility as a prime consideration of the new age, the divisional artillery could be decreased somewhat and a larger degree of direct support of the infantry assigned to corps artillery.

What emerged was the pentomic division's own heavy firepower concentrated in a battalion of 105-mm. howitzers made up of five 6-gun batteries for direct support and, for general support, one 4-gun battery of 8-inch howitzers, one 2-launcher battery of Honest Johns, and two 6-gun batteries of 155-mm. howitzers.

In the new pattern, as far as totals are concerned, the arrangement employs an identical number of weapons, with one signal exception—instead of twelve of the 155's there will be no fewer than thirty. And, quite as important, instead of concentrating all direct support for the division within one battalion, there will be five battalions, one for each of the division's five battle groups.

Thereby much more firepower becomes immediately available not only to the division as a whole but, notably, to the battle group commander who in the new concept is at last acquiring the power to match the high degree of responsibility which is necessarily being placed upon him by reason of the wider dispersion of total forces both in width and depth.

Each of these new artillery battalions which are organically a part of the battle group will have two batteries, one of them composed of six 105's, and the other of six 155's. (The four 8-inch howitzers and the two 2-launcher Honest Johns will remain in the divisional general-support unit as at present.)

Of the five composite battalions referred to, three will be towed by tractor and two will have self-propelled guns. If wishes were only SP guns, all five battalions would be self-propelled. Plain poverty at present makes it necessary to use tractors for two.

The self-propelled 155-mm. Long Tom gun also served well in Korea (Army photo).

During World War II, Marines on Rendova Island had to dig an emplacement for this towed 155-mm. Long Tom gun before it could be fired (Army photo).

An artillery gun crew fires the towed version of the 105-mm. howitzer during the Korean action (Army photo).

The new T195 test model of the 105 howitzer is a completely tracked, self-propelled weapon (Army photo).

It is easy to see that, by the new pattern, arrived at fortunately before the Army's tactical training program was too firmly committed to the overly thin direct support of the original plan, the new group of the pentomic division is acquiring a very substantial and effective strength.

Quite as important, the group commander gains at the outset that full control of the artillery he will need for his own support and hence, logically, for his own combat planning. Instead of a mere one-fifth share of thirty 105's and twelve 155's—an asset on which he might find it difficult to make prompt collection in an emergency—he now knows from the beginning that he will have all six 105's and all six 155's, plus the customary general support of the 8-inch howitzers and the Honest Johns as formerly.

THE great power of the additional 155's—thirty instead of twelve for the full division—is welcomed by field commanders who had been uneasy about the pentomic division's original method of acquiring high mobility at the expense of firepower. Speed of support can be almost as effective as volume, and there is no substitute for precision in emergency.

Veterans of World War II fighting in North Africa and Italy and Western Europe have never forgotten the difficulties they encountered from German 88's, well emplaced and firing with such precision that they seemed to be more numerous than they actually were.

Nor have German veterans of the Eastern Front ever forgotten the Russian artillery support; and it may now be noted that trusted reports indicate that today's Russian artillery is using larger calibers than employed by the Soviets in World War II.

Our own Long Tom was and is a fine gun, but we need more 155's, of present or improved type, with self propulsion—many more, as is shown by

The M53 standard model of the 155-mm. self-propelled gun is mounted on an improved full-tracked carriage and has an armored cab and a cal. .50 machine gun. Top speed is 35 m.p.h. and cruising range 150 miles (Army photo).

our projected use of three battalions of towed guns along with two of SP's, simply because we are oversupplied with the one and undersupplied with the other.

AN historical diversion will explain a remote cause of this situation. We came out of World War I with our first real breakaway from horse-drawn guns (and in that break we were ahead of several other nations) with a fair start on 5- and 10-ton Holt tractors as prime movers for our 155's and our big 240-mm. howitzers, our largest field piece of that day.

The postwar Caliber Board (better known as the Westervelt Board, from its distinguished chairman) surveyed the Army's requirements, balanced them against the Nation's industrial capabilities at that time and for the surely predictable future, rejected the horse-drawn type altogether, considered the possibility of mounting the gun on its own motorized carriage (the tank's own design was an encourager) weighed the maintenance cost and complexity of separate gun and tractor against those of the gun-tractor in combination, and decided for tractor towing.

The reason for the choice was persuasive, at the time. In the early 'twenties the automobile was far from its present efficiency and, because maximum reliability under all conditions is a *sine qua non* of Army equipment, the board understandably felt that it had, at that time, to reject the self-propelled concept in favor of tried and true towing.

In the past, times without number, if a horse fell dead another horse was hooked up and the gun kept moving. Likewise, if a tractor should fail, another could be hooked up to haul the gun into action; but if any of the many parts of a self-propelled gun should fail, the Board reasoned soundly enough, the weapon might be out of action indefinitely. In brief, the Army of that day was reluctant to hang a reliable and all-important gun on an unreliable carburetor.

That reasoning was sound in the early 'twenties. Unhappily, in the succeeding decade the carburetor and everything else about the automobile (except perhaps the driver) gained enormously in reliability, and what had been true of motors in the 'twenties was no longer true in the 'thirties. But instead of adjusting concepts to the times, the Army continued under the spell of the Caliber Board's propulsion doctrine for two decades.

In 1941, experiences abroad resulted in an urgent but belated cry for SP guns, and Ordnance did a crash job of modifying the 75-mm. M2A3 by welding it onto a half-track vehicle and sending it to the Philippines. Then a more deliberate job was done with our new 105-mm. howitzer and 40-mm. gun as well as the new "quad" machine gun.

Then, in another shotgun marriage under ceaseless pressure from the field, the 40-mm. was mounted on a light-tank chassis, and the "Priest" was constructed with yet another chassis plus the 105 howitzer. Then came a light-tank chassis combined with our reliable 75-mm. pack howitzer; the latter had long been a success with a mule mount—and still would be, as Brig. Gen. John W. Cave remarks, except for the greater difficulty with lead time for mules.

TODAY the Army is completely sold on the self-propelled gun, but it still has a plethora of those World War II towed guns which do not wear out fast, and experience says we are going to use them up before we get new self-propelled guns in quantity.

The principal shortages of self-propelled types are in the 105's and 155's. How would we get them? From industry, of course; and here we discern a painfully standard ratio between production readiness and purchase cost. Thus, if we keep a production line in stand-by we will need 1½ years to get prime and secondary contractors into full swing and production at the desired pace.

Maintaining that stand-by state will cost, say, X dollars a year. But if we wish readiness to produce in one year, it will cost 2X dollars to maintain such a state. If we want readiness in six months, 4X dollars; in one month, perhaps 10X dollars. True readiness is expensive.

Now our laid-away production base has been figured as worth several billions of dollars; we budget $32,000,000 a year—that is, less than one per cent—to keep it at what we politely call readiness. How "warm" is our mobilization base, really? How soon will it produce? How much will production cost? What is the life of the stuff? What is our time of greatest danger?

GETTING away from mobilization frustrations and over to Ordnance research and development, we find two items of outstanding interest in this matter of self-propelled guns. One is the self-propelled T195 (to replace the M52 for mounting the 105) and the other the T196 (to replace the SP M44 for mounting the 155 howitzer).

Here are some of the measures of improvement: the new self-propelled 155 will practically double the old 75-mile cruising range; it will cut the old weight from 64,000 to 41,000 pounds, a matter of significance in air transportability and in amphibious operations; it will reduce the old silhouette height from 122 to 110 inches, and ground pressure from 9.4 to 8.12 p.s.i.

Besides an improved carriage, the cannon will have better range, greater precision, greater lethality, and greater speed of action. This adds up to a good deal of improvement.

Are we getting these new self-propelled guns in quantity? No. We do not get them without money (perhaps $90,000 per unit), and the Army is faced with the usual choice of putting money into cannon or into equally needed other items in the long list which made up the $3 billion a year that Gen. Maxwell D. Taylor lately urged as a 5-year need for a modernized Army.

It is significant that in divisional organization the missile has not yet taken over the role of the gun nor the atomic warhead that of the conventional shell. There still is no virtue in overkilling, no desire to expose our own men unnecessarily to our own fire, no justification, either economic or military, to use the expensive modern equivalent of three battalions of artillery when one well-placed and economical 155-mm. shell will do the job.

Broken-backed Warfare

With the ever-present possibility of a surprise nuclear attack upon the United States, industry must be prepared to carry on its support of the armed forces despite losses in manpower and plant facilities

Col. Virgil Ney

AMONG the protagonists of total war there are those who claim that, in view of the current threat of nuclear weapons, there must be some method of continuing to fight, even under the conditions of almost nuclear destruction. That such a condition will occur and can exist in the event of the unleashing of the horrors of a nuclear holocaust must be recognized and planned for by those in authority and responsible for the continuity of a combat effort for national survival.

What one does in conventional war —that is, war waged with gunpowder and nonatomic agents or weapons, when conventional aircraft bombing has disrupted the economic and industrial bases of the war effort—is fairly clear.

Dispersal, the use of alternate or dummy locations for factories and industrial complexes, the shifting of industrial and military populations, the literal "going under ground" are all antidotes for conventional bombardment well known to the practitioners of the art of war, and during World War II all the nations engaged conformed to this general pattern of defense.

However, with the advent of atomic and nuclear weapons, the entire art of conventional warfare has been upset by the nonmilitary scientist who has developed a weapon, the optimum use of which the military professional does not as yet understand. Terrible even in contemplation, the hydrogen bomb, by its controlled tested effect, at least seems to have temporarily inhibited the practice of the art of conventional war.

Colonel Ney, United States Army, Retired, is now a research specialist with the Foreign Area Studies Division, American University, Washington, D. C.

Now that the Nuclear Age is upon us, many military thinkers are of the opinion that conventional warfare has become almost archaic and nearly impossible of prosecution, except under the guise of "limited war." Obviously the reason for the inability of conventional war to function on a grand scale today is the threat of atomization by nuclear weapons of military mass formations and the industrial and population complexes which support the combat effort.

Today modern armies are faced with a multitude of complex problems. One of the most pressing of these is the lack of any clear concept of the probable ground patterns of the tactical operations of units maneuvering under nuclear weapon attack. There are those "experts" who predict that future wars may be of duration measured in days or even in hours and that the war will be over before any type of conventional national mobilization can be effected!

In conventional war, ground and its possession is a determining factor in defeat or victory. *No bomb or missile can take and hold ground.* Therefore, unless complete destruction and desolation is accomplished upon an enemy area, men on the ground must take and hold it—regardless of how it was "softened." It follows that if any human life is left in the area, it will possess some nucleus of resistance to the appearance of hostile occupying ground forces by the utilization of "broken-backed warfare" and similar techniques for repelling the enemy.

ONCE a nation finds itself in rubble with its armies destroyed, immobilized, or dispersed and with communications damaged, some method of air, naval, and ground combat will be used to continue the struggle unless there is total annihilation. Statistically it can be shown that even under the most severe nuclear bombardment, some human life will survive. Whether or not the survivors will have the ability to reorganize and offer broken-backed resistance as such will not be known until that resistance begins. Preattack planning should therefore include detailed provision for the initiation of this post-attack broken-backed combat.

National planning for war should include the most detailed plans for the waging of war with limited or crippled industrial and manpower bases. That atomization of large industrial areas

will deprive the all-out war effort of its most vital life blood—the tools and weapons produced by industry for war making—must be assumed as certain. Stockpiles of the critical essentials for war may be destroyed by the action of a single bomb strategically placed by an informed and alert enemy.

Among the facets to be considered when planning for the operation of broken-backed war are the following: land mass area available and suitable for dispersal of industrial, military, and civilian population center complexes; resources on hand and available for war making; the type of retaliation contemplated; the weapons required; the calculated risks involved in depletion of resources on an all-out massive retaliation basis; the stockpile of raw materials and accessible sources; the public morale and temper; the condition of the enemy; and the possibility of internal domestic difficulties, which would hamper our conduct of broken-backed warfare.

Such warfare must be contemplated as a concomitant of war waged with nuclear weapons. As indicated previously, the industrial and population complexes are directly involved. The role of the military in broken-backed warfare is not quite so well defined.

What use should be planned for the military manpower not able to be deployed for combat in repelling a domestic landing of an enemy from air or submarine fleets? Should not some thought be given to the idea of including a modicum of industrial training for the huge masses of men who may never fire a shot in anger?

Why not an additional skill in some form of wartime factory work for every member of the armed forces—to be utilized *only* when he cannot be employed in combat and the industrial labor force has been severely crippled by a nuclear holocaust? Cannot alternate plans be devised, which will provide for the replacement of labor-force casualties by military personnel who are not required for the military mission?

These ideas are not unthinkable to the professional industrialist whose responsibilities in war always have been to provide the soldier with the so-called sinews. Without the sinews, war of any description—conventional or nuclear—will not be waged for long.

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It therefore becomes increasingly clear that *all* planning for broken-backed war must be prepared in advance in final form and available for execution without delay in the event of such hostile attack. There will be no time for political quibbling or indecisive speculation as to what to do!

If the Nation is to survive—if the Americans as a people are to continue to exist—the plan for broken-backed war must operate much as a preplanned national standing operating procedure—without approval or leadership on the part of any legislative or executive body whatsoever. Unless we can be prepared to function in such a manner, we already have had two strikes called on our chances of survival.

Every industry in the Nation must have a plan for automatic operation under the requirements and conditions of broken-backed warfare. Obviously there are several considerations to be considered carefully by government and industry with relationship to the conduct of industrial operations under the conditions mentioned.

Of overriding importance is the matter of geographical location of the industrial complexes concerned. What is the vulnerability of their location in consonance with the assumed and predicted critical target areas within the United States? Are they located near cities or away from the normal abodes of the labor force? Are they cited on plains or in mountains or valleys where the conformation of the ground will give some protection from blast effect or, in the case of a location on plains, increase the chances of total destruction of factory, personnel, and raw and finished materials in the area?

To the average citizen, industrial security means protection against sabotage and the infiltration of foreign agents and spies. In view of the present condition of flux in the field of international relations, cannot industrial security be given a more inclusive definition or meaning? This factor of broken-backed warfare soon will become increasingly important and critical as the phase is developed into a meaningful application of national policy. The writer does not presume to tell how this will be done—only how, in his opinion, it should be done—if America is to survive a nuclear conflict.

THE role of the military in so-called broken-backed warfare has not been well defined. Assuming that in a nuclear war the land armies will be inhibited from action by the nature of the conflict, there must be some method prescribed or planned by which the tremendous manpower involved in the service can be used and used effectively against the nuclear-weapon wielders. With no invasion threat to this continent in event of nuclear war what will be the mission of land armies? Will they be kept mobilized to do nothing, awaiting death in mass formation? Will they be dispersed and immobilized? Or will they be used to supplement and to replace those of the industrial labor force who have become casualties?

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To do this will take the best preattack planning of the responsible defense agencies concerned. When the attack arrives there will be no time for dispersal, retraining, and reassignment of military and industrial personnel in order that the war be carried on and that we retain the capacity to inflict mortal injury on our enemy—even though the Nation's industrial back is broken.

Within the structure of national defense there must be provision for planning for broken-backed war on the highest General Staff or Joint Chiefs of Staff levels. The connection between the industrial preparedness and educational programs fostered by the Defense Department and discussed and studied within the curricula of the Industrial College of the Armed Forces must be defined and established on a working level and not on a theoretical basis. This planning should be developed to the point where national and local industries participate.

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OBVIOUSLY, much reeducation will be required to indoctrinate America in the matter of such warfare. Labor, including unions and management; government, including politicians, generals, and admirals; and the general public will be under the necessity of reorientation for the task of survival in the war of the future. Much more is involved in that struggle than victory. What is involved is survival with victory!

There is some question about the possibility of victory in a nuclear war. Some people hold to the thesis that there can be no victory for either side once atomization begins. This theory is not one of realistic thinking. He who is able to continue regardless of injuries, to fire his weapons in any type of war, nuclear or conventional, is still in the fight and *always* has the chance that the enemy will give in or decide to negotiate.

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The concept of the military posture, presently held by the average American, of necessity will have to be altered and abridged somewhat by this type of planning. In this connection it should be noted that the desideratum here is survival. With this concept in mind, short cuts, and policy improvisation will be the order. To put it bluntly, many, yes, most Americans, will have to forget some of the things they accept as commonplace and substitute the unusual if they are to survive.

The military forces of the United States must be prepared for the following—in the event of nuclear warfare: (1) Combat—ground, air (missile), sea; (2) Industrial back-up (labor force) for those military personnel not able to be used due to the tactical situation in combat. These personnel will be skilled or semiskilled military persons who can be readily "converted" in accord with preattack plans to carry on the industrial base for the broken-backed war; (3) Operation of strategic plants and industries in event that civilian managerial staffs are not functional due to casualties; and (4) Wage guerrilla warfare against an invader of the United States in event dispersal and nuclear destruction (including fallout lethality) makes concerted military effort impossible. This must be automatic on a standing-operating-procedure basis individually and collectively.

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The Soviet attitude toward broken-backed warfare may be ascertained from the amount of preparation which has gone into Soviet civil-defense programming, especially for the industrial areas and the individual factory complexes. Without doubt, the Russians are as well prepared for the receipt of an initial devastating nuclear blow as is any other nation at this time.

REGARDLESS of the Soviet attitude and the apparent conversion of the top-level strategists to a more realistic approach to the problem of "who fires first," the terrible and real dangers of preemptive (surprise) attack are always with us. What this means to the United States and its defense posture are too obvious to be passed over lightly. Briefly, it dictates our policy of defense, which we as Americans must live with and carry out if we are to survive.

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would be uncertain from the points of view of possible employment and, most importantly, of survival. What plans are to be formulated for them, as ground combat troops, will of course, depend upon the military situation at the moment. If the nuclear exchange becomes a matter of who survives with enough physical strength to place the final ICBM on the launching pad—it would appear that ground troops may be wasted as potential against the attack of the enemy. If there is no intention or possibility of moving troops into nuclear combat and conventional occupation situations, a more profitable use must be made of them.

IF, as indicated in the event of the preemptive attack, the war becomes a matter of continuation of the nuclear missile exchange, then surely the number of individuals involved will, of necessity, be minimal. As far as a nation in this area of the world is concerned, because of the ground, sea, and air distances, a combination of nuclear exchanges and conventional ground-force action does not seem feasible unless command of the air by conventional attack aircraft would permit unlimited airborne troop transportation.

The objectives for such operations must be definite and clear. They must be attainable strategically and tenable tactically. That expeditionary forces would be required to occupy contaminated areas (or would want to) is highly questionable. It appears that this frustrating situation would be applicable to both sides in a nuclear war.

With the threat of preemptive attack by the Soviets hanging like the sword of Damocles over the heads of the Western nations, it behooves the leaders of the free world to be more than adequately prepared to wage broken-backed warfare. Indeed, it is the sincere conviction of the writer that this kind of warfare may be the only kind that will be waged by anyone in the event of a nuclear conflict.

How this is to be done may be somewhat sensed by a careful study of the *modus operandi* of Soviet civil defense—at least some of the information available may give some usable clues. What the enemy camp expects from us and what we are "prepared" to receive from it may be an equation worthy of study and solution in order to forecast the future of the two titans and the rest of the world generally.

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Preattack dispersal of industry and population is one sound solution to this most complex and bewildering problem. At least, dispersal will provide the protective ground space with adequate industrial "maneuver" and "living" room. But dispersal must be accompanied by the provision of underground installations of factories and living quarters for the labor force as integral parts of any planning for industrial survival of the United States in a preemptive attack.

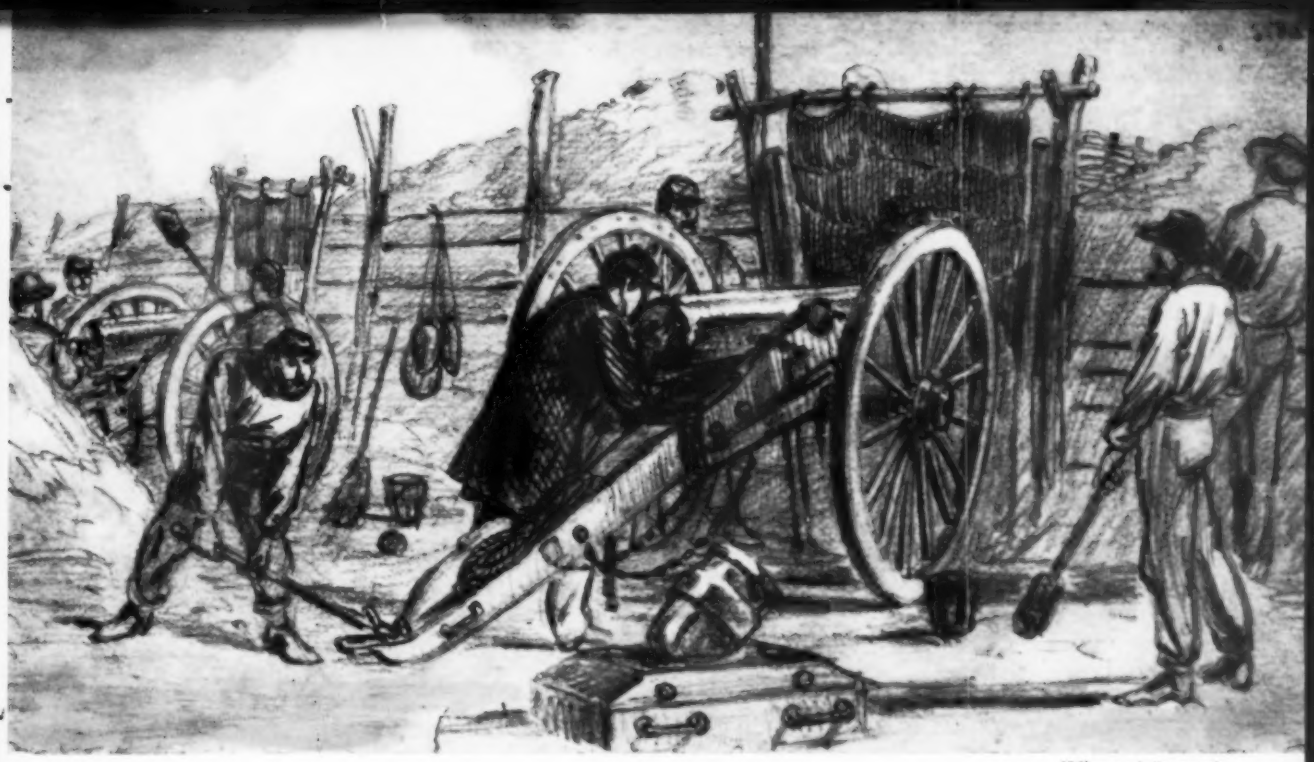
In the United States, civil defense is, of course, voluntary. There is no compulsion for participation of the general public in civil-defense training as in the Soviet Union. The present program of civil defense in the United States provides for survival on a national scale. This planning is based primarily upon evacuation (assuming a minimum warning time of two hours), and there is considerable attention paid to the "saving" of as much industrial equipment and transportation as possible.

Industrywise, civil defense does have a program, but there is much to be desired if it is to be effective under attack conditions. The apathy of the general public has crept into the industrial ranks, and it is the writer's opinion that civil defense is given considerable lip service by those in authority. This condition must not be allowed to continue. If it does, the Nation will not be able to begin broken-backed warfare, let alone survive! Some compulsory features must be enacted by legislation at once if certain critical and essential industries are to be able to function in event of war. The issue is clear—the citizens of America must forget politics and do something about survival *now!*

From a hurried study of the civil-defense program of the Soviets, both for the civil population and industry, it can be seen that the U.S.S.R. is preparing (and is now prepared) to wage broken-backed warfare. By their preparedness they have signaled their intention in the event of nuclear warfare. Can we, the guardians of the bastion of freedom for all men, do less and survive and win?

While the aerial bombing of World War II will seem somewhat remote and prosaic compared with the claims of destruction predicted for the 20-megaton monsters of future nuclear conflict, the bomb destruction rained down from the skies upon Germany during World War II did require the operation of broken-backed warfare.

Planning for such warfare should be an activity of first priority in every establishment of the armed forces of the United States and of all American industry. The coordination of planning between industry and the armed forces planning specialists must be developed, maintained, and accomplished with only one thought in mind—to have the answer to the Soviet threat of preemptive attack ready when and if it comes. Nothing less will do for America if she and her ideals of the freedom of man are not to perish from the earth in the awful heat of nuclear combat.



(*Library of Congress*)

Maj. Alfred Mordecai

The first Ordnance officer to apply scientific methods to armament

Stanley L. Falk

THE 50-year period ending with the close of the American Civil War was one of unprecedented progress in military technology. In the half century between the Battle of New Orleans and the surrender at Appomattox, the effect of the Industrial Revolution on the tools of war was so great as to constitute a technological revolution in military arms and equipment.

This technological revolution introduced scientific research and development to the military art. It provided more exact methods of testing materials by instituting careful investigation, controlled experiments, and applied laboratory proof. It made sciences of metallurgy and ballistics, instead of the educated guessing games they once had been. It revolutionized production methods and laid the groundwork for a modern arms industry.

Mr. Falk is in the Office, Chief of Military History, Washington, D. C. The career of Major Mordecai was the subject of Mr. Falk's dissertation for his Ph.D. degree awarded recently by Georgetown University, Washington, D. C.

These advances, in turn, opened the way for the development of modern arms: a practical breech-loading repeating rifle; a rapid-fire machine gun; heavier, rifled, breech-loading artillery; better and more efficient ammunition; and greater uniformity and durability in weapons and equipment than had ever before been thought possible.

In the United States, the achievements of this era were made possible by a small group of inventors and scientists who labored to produce better military weapons, ammunition, and equipment. The work of those members of the group who wore the uniform of the United States Army is less well known than that of their civilian colleagues. It was, however, of greater importance, for those officers not only provided guidance and encouragement to civilian inventors, but they also made many other more direct contributions. Above all, they introduced applied science to the American Army, and made it a permanent part of military research and development in this country.

Maj. Alfred Mordecai was one of these men—a leader in technical mili-

tary research and in the practical application of science to war. Like his fellow officers, he was the product of an antimilitaristic national tradition and was educated more thoroughly in technical than in military skills.

The United States Military Academy, where he was trained, was a scientific institution rather than a school for war, and it was small wonder that the men it graduated were more technologists than soldiers. Engineers, ordnance experts, even artillerists wore the Army uniform but were, in fact, closer to their civilian counterparts than to some of their military colleagues.

Each was a specialist in his own field; few were experts in the broad military art of war. Yet their contributions to the Army were greater and more lasting than any others in this period of American history.

MAJOR Mordecai was typical of the soldier-technologists with whom he served and with whom he shares his anonymity. A biographical study of the man as soldier and scientist, of his background, attitudes, and problems, and an investigation of his contributions to the development of the United States Army provides a key to the type of officer who helped to make the technological revolution and to apply the great advances of the age to the tools of war.

Mordecai's military career, from his entrance into West Point in 1819 to his resignation from the Army in 1861, spanned almost the entire period of the technological revolution. As an engineer first, but more importantly as an Ordnance officer, he actively participated in the major developments in American military technology that took place during this era.

His contributions were broad and numerous, but they all lay within the great and enduring achievement of the technological revolution: the application of science to war, and, by means of the scientific method, the development and systematization of new weapons, ammunition, and equipment, or the improvement of old, through years of careful investigation, observation, experimentation, and testing.

"My ability," he wrote at the close of his military career, "consists in a knowledge and love of order and system, and in the habit of patient labor in perfecting and arranging details; and my usefulness in the Army arises from the long-continued application of these qualities to the specialties of my habitual business."

> *"The soldier-technologist was a scientist before he was a soldier. He was technically trained, mechanically skilled, and scientifically oriented. . . . He was not unaware of his responsibilities as a soldier, and he rose to them when necessary. But he was first of all a technologist who happened to be a soldier, rather than a military man with a knowledge of science."*

Within this general consideration, Mordecai made his contribution in many areas: in the systematization of American artillery and small arms, in endless experiments and tests of weapons and ammunition, in the adaptation of European advances to American military technology, in increasing the Army's knowledge of ballistics and metallurgy, and in countless other invaluable ways.

His contributions, as one of his younger contemporaries wrote later, "came not in the shape of a few large nuggets but in a steady stream of gold dust sustained for many years and far outweighing the nuggets in the end." His work was valued for its accuracy, its precise and systematic nature, and its immediate applicability.

Born in North Carolina in 1804, the son of a merchant and educator, he was graduated from the Military Academy at the top of his class in 1823. For nine years after his commissioning, he served his country as an Engineer officer. He taught at West Point, helped supervise and inspect the construction of fortifications along the Atlantic Coast, assisted in a canal survey, and served as Assistant to the Chief of Engineers.

In 1832 an Army reorganization opened several positions within the Ordnance Department. Competition for these posts was strong, and all save one went to artillery officers. Mordecai, an Engineer, who had not sought an Ordnance position, was chosen for the remaining post at the recommendation of the Chief of Engineers. His transfer and commission as a captain in Ordnance anticipated by many years the date when he would have reached that rank as an engineer.

During the twenty-nine years that Mordecai served as an Ordnance officer, he rose to the rank of major, held many important positions and commands, and was sent on several consequential missions. He commanded the Frankford, Washington, and Watervliet Arsenals, holding the post in the Nation's capital for more than a decade, including the Mexican War period when the arsenal was a vital ordnance supply point. He was assistant to the Secretary of War and to the Chief of Ordnance. He published a handy and useful Digest of Military Laws (1833), served on the board of visitors at West Point, helped to revise the Army Regulations, and was sent to Mexico to investigate a fraudulent claim growing out of the Mexican War.

HE made his greatest contributions as a member of the Ordnance Board which passed on or developed all new weapons, ammunition, and ordnance equipment for the Army. An original member of the Board, and serving on it for more than twenty years, he was an important participant in its proceedings.

The Ordnance Board was formed initially to standardize and systematize Army ordnance equipment. It developed a much broader role, however, through its assumption of the necessary functions of supervising and directing the test, evaluation, and design of this equipment.

It thus became probably the most important single factor in the growth of military research and development in the United States prior to the Civil War. Above all, it was responsible for the introduction of the scientific method to American military technology, and Mordecai, in the forefront of research and experimentation, shared this achievement.

The work of the Ordnance Board was devoted as much to systematization and standardization as it was to research and development. Mordecai and his colleagues formulated the first complete system of artillery for the United States Army, and his role in the collection, evaluation, and meaningful organization of the vast mass of data studied in order to devise this system was an outstanding one.

It was he, moreover, who was assigned the important task of coordinating these efforts of the Board, writing the group's report, and drawing the plates for it. His work was published in 1849 as "Artillery for the United States Land Service."

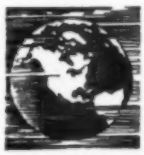
In the same way, he did most of the work on the first Ordnance Manual ever published by the United States Army (1841) and alone was responsible for the second edition (1850) of that important volume. He also helped to draw up several editions of the Ordnance Regulations.

As a part of this general work, Mordecai and a few colleagues were sent abroad in 1840 to study European methods of weapons production, and again, fifteen years later, he was dispatched to observe the Crimean War and further to study European arms systems and military establishments.

THE reports that he and his colleagues compiled on these trips were of great value to the development of American military technology. His observations on his Crimean mission were published by the Government as "Military Commission to Europe in 1855 and 1856: Report of Major Alfred Mordecai" (1860; second edition, 1861).

Complementary to Mordecai's work on the Ordnance Board were his experiments with artillery and gunpowder, the results of the most important of which were published in 1845 as "Report of Experiments on Gunpowder," with a sequel in 1849. These were of particular value to the Ordnance Department and were distributed throughout the Army and to private powder manufacturers, scientific societies, and educational institutions, and were studied at West Point. Translated into French and German, they were well received in Europe, and it was by this contribution that Mordecai was best known to military technologists abroad.

When civil war split the Nation in 1861, Mordecai was assailed by divided loyalties. Torn between conflicting ties with North and South, subject to pressures and suspicion from both sides, he deplored the great conflict then unfolding and, when he could delay no longer, made the only decision that logic and necessity allowed. With heavy heart, he resigned from the Army and retired to civilian life to maintain a scrupulous and unhappy neutrality throughout the war. He lived on in Philadelphia with his family until his death in 1887.



The military career of Major Mordecai was typical of scores of other soldier-technologists whose merit was greater than their fame and who share with him the credit for the achievements of the technological revolution. From this study, therefore, it is possible to draw some general conclusions about him and his fellow Army officers, the architects of the nineteenth-century revolution in American military technology.

"Mordecai made his greatest contributions as a member of the Ordnance Board, which passed on or developed all new weapons, ammunition, and ordnance equipment for the Army. An original member of the Board, and serving on it for more than twenty years, he was an important participant in its proceedings. . . . The Board became probably the most important single factor in the growth of military research and development in the United States prior to the Civil War.

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The soldier-technologist was a scientist before he was a soldier. He was technically trained, mechanically skilled, and scientifically oriented. He was pragmatic, meticulous, systematic, diligent, and cautious. He had curiosity, imagination, initiative, and tenacity.

He filled page after page of neatly kept record books with myriad data gathered through careful experimentation or observation, but abstract or theoretical questions did not interest him as much as the application of these data to the solution of practical military problems. He worked slowly and methodically, always with a definite end in view. His conclusions were reached with painstaking care, and were never immutable.

The soldier-technologist was not a machine, but shared, in general, the traits and habits of other educated men. He read, was interested in politics, thought about social and economic questions, traveled when he could, and complained about the difficulties of his profession. He was neither a recluse nor did he seek friends only among his fellow technicians. Rather, he mingled with society, raised a family, and enjoyed a wide circle of acquaintances.

HE was not unaware of his responsibilities as a soldier, and he rose to them when necessary. But he was first of all a technologist who happened to be a soldier, rather than a military man with a knowledge of science.

The soldier-technologist was not alone responsible for the technological revolution, but it could never have occurred without him. In addition to his own multiple contributions, he took the work of others and shaped and transformed it to fit the peculiar requirements of the military profession. He introduced applied science to the United States Army and so bestowed on it a legacy it has never relinquished.

New Combat Vessels

The U.S.S. HAZELWOOD (DD-531), above, is the first Atlantic fleet destroyer to employ operationally the new Dash system which flies a remotely controlled helicopter from a special deck to deliver antisubmarine weapons (Navy photo).

The 447-foot, atom-powered, radar-picket submarine TRITON, above, is the world's largest and most powerful submersible. The 380-foot submarine PATRICK HENRY, shown being launched below, is designed to fire Polaris missiles while submerged.

Testing Nuclear Ordnance

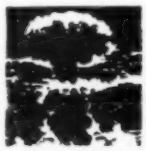
Desert laboratory subjects missile components to environmental changes to meet the modern challenge of aerodynamic heating, high-intensity noise, launching shock, high acceleration, and radiation

William A. Gardner

BECAUSE the military requirements for nuclear weapons have become increasingly more rigorous over the past decade, those responsible for developing nuclear ordnance have had to seek out new and more effective testing techniques. For example, scarcely fifteen years ago, engineers questioned whether the problem of high-drag rise experienced near Mach 1 could be solved.

This so-called impenetrable wall came to be known as the "sound barrier"; but during the ensuing fifteen years, aerodynamicists and physicists, utilizing the supersonic wind tunnels, the sled tracks, and the design tools of their professions, not only crossed the "impenetrable" barrier but greatly exceeded it.

A primary problem today is the so-called "thermal thicket," that high-speed area where aerodynamic heating begins to destroy the delivery vehicle and its atomic weapon. As the weapons designer pushes to meet the challenge of greater and greater speeds in the delivery of nuclear weapons, he must cope not only with the thermal thicket but with other and newer problems caused by such factors as the high-intensity acoustical noise developed by the power plants of high-powered engines; the sustained high accelerations developed during launching, separation, and reentry; the radiation from the nuclear power plants of the future; the shocks of special delivery techniques, and many others.



Mr. Gardner is manager of the Test Laboratory Department, Sandia Corporation, Albuquerque, N. Mex.

In the ordnance engineering of the atomic weapon, the environmental requirements for each new weapon program are set forth in a document called "The Stockpile-to-Target Sequence," forwarded to the appropriate facility by the Department of Defense through the headquarters of the Defense Atomic Support Agency in Albuquerque, N. Mex.

This document, which accompanies the military characteristics for the system, provides the background data necessary for the establishment of an environmental test program. It describes the environmental conditions which a nuclear weapon may be expected to experience between manufacture and delivery to a target. With these background data—and experience gained in other development programs—it is possible to establish a test program for the new system.

To implement this test program, the Sandia Corporation, a nonprofit subsidiary of Western Electric Company and a prime contractor to the Atomic Energy Commission, has developed a number of unique environmental test facilities at its desert location near Albuquerque, N. Mex. Planning for this desert laboratory, designated Area III, began in 1952; by July 1953, the first facility, a 1,000-foot velocity track, was in operation.

Since 1953, these facilities, necessarily located some distance from the main laboratory and operated by remote control, have been used to conduct tests that may be hazardous to personnel and permanent facilities.

OFTEN, test weapons and components may contain high explosives or other dangerous materials or the components may break up during high G testing and create the hazard of flying fragments. To obviate these hazards, the Area III test site is laid out in facility areas which are equally spaced from a central point from which the facilities are controlled and to which information is relayed by direct wire.

A versatile basic tool in the environmental test program is the hydraulic centrifuge. Because of its size and capacity, the unit is useful not only in obtaining sustained accelerations but can be used, with the addition of temperature shrouds, vibration equipment, and other accessories, to obtain various combinations of environments.

The centrifuge, one of the largest in the world, is powered by thirteen 100-horsepower electric motors which drive hydraulic pumps to provide a hydraulic pressure of 5,000 p.s.i. to the head of the

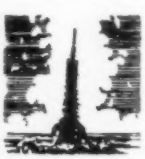
centrifuge. The head was designed to withstand a maximum unload condition of 500,000 pounds of force; it can accelerate 9,000-pound test components up to 50 G's, and smaller test loads of 2,000 pounds have been tested to 240 G's. Components ranging in size from 74 inches in diameter and 144 inches long can be tested.

A CLIMATIC and high-temperature chamber is now under construction. The combined chambers will make possible thermal shock testing which simulates such conditions as the release of a weapon from a bomb bay heated to 500 degrees Fahrenheit into an outside temperature of minus 65 degrees Fahrenheit. The facility, contained in one building and connected by a remotely controlled track and cart, consists of two chambers:

1. A climatic chamber which measures 10½ by 12 by 35 feet. Test temperatures in this chamber will range from minus 100 to 250 degrees Fahrenheit; relative humidities from 5 to 100 per cent; and altitudes from 2,500 feet below sea level to 100,000 feet above. The climatic chamber also is partitioned in the middle to allow separate temperature tests to be conducted simultaneously.

2. A high-temperature chamber which is an oil-fired oven measuring 10 by 10 by 25 feet. Test temperatures in this oven range from ambient to 1,300 degrees Fahrenheit.

A second high-temperature environment imposed on weapons systems in the laboratory is the simulation of the heat pulse experienced by a body reentering the atmosphere from a ballistic-missile flight or returning from a satellite trajectory of boost-glide flight. Typical of the critical problems arising during high-temperature reentry are the structural failures and severe thermal stresses caused by the high heat levels, and the subsequent conduction of this high-temperature pulse to internal components.



Now being constructed at the laboratory is a radiant-heat facility designed to simulate as closely as possible the heat pulse and heat transfer rate of various reentry conditions. The new facility consists of a series of electrical resistance heaters which can be arranged about the test component.

With the new facility, about 20 square feet of a typical test vehicle will be heated up to 500 Btu's per square foot per second. To attain the necessary high-temperature levels the facility requires a power input of more than 13,000 kv-a, and this power will be controlled automatically.

A third temperature facility is a mobile temperature trailer used to establish temperature-conditioned environments in combination with vibration, shock, or other factors. When the trailer is in use, a shroud or insulated box is constructed around the test item which is later connected to the trailer by a 2-foot-diameter flexible tube. The trailer makes possible a temperature-conditioning range from minus 100 to plus 225 degrees Fahrenheit.

To reproduce the gamut of mechanical shocks that nuclear weapons may experience during transportation, handling, and delivery, several full-scale devices are employed. In comparing these facilities, the maximum velocity change attainable on the weight of a specific test item is used. Velocity change may be described as the integrated area under a time-acceleration curve, or the shock signature imparted to the item under test.

For instance, on a free-fall test unit dropped from a height of 300 feet, the terminal velocity upon impact with the ground would be about 135 feet a second. The conversion of this velocity into a shock signature—or the time and shape of the deceleration pulse—would be dependent upon the configuration and materials of both test unit and the impact area.

The 300-foot drop tower, which supports a cable anchored into the ground at a 45-degree angle, is used to test components weighing up to 3,000 pounds. Test components may be dropped vertically from the cable or dropped down the cable on a simple carriage. Velocities attainable on this system are 130 feet a second vertically and 60 feet a second horizontally.

A second shock facility, the shock-cord accelerator, subjects weapons to forces which simulate missile launch, catapult launch of aircraft, aircraft arrestment, power failure on take-off, ditching, and other special conditions of transportation and handling. It can accelerate 18,000-pound specimens to 17 G's or more.

The shock-cord accelerator, comprised of a sled powered by bungee cords, rides a short length of track. When stretched to nearly twice their length, the one thousand ⅛-inch-diameter bungee cords can apply an accelerative force of 500,000 pounds. Velocity change attainable with this large slingshot is 89 feet a second.

A THIRD device is a 3,000-foot track with a normal railroad gauge of 4 feet, 8½ inches. Used on the track are test-track sleds powered by various combinations of dry-propellant rockets. Shock testing is conducted on this track by accelerating the test component and sled into free flight off the end of the track.

The sled and components impact the various targets at velocities up to 2,600 feet a second. High-speed photography and telemetry systems similar to those used in the free-flight testing of bombs and missiles are used to monitor the tests.

A fourth shock-test device is an air gun consisting of two 16-inch naval rifles, fabricated by the Naval Weapons Center, Washington, D. C. The rifles, machined to an inner bore diameter of 26 inches and 90 feet in length, were flanged and bolted muzzle to muzzle to provide an airtight compression chamber. Velocity changes up to 500 feet a second can be produced in this gun which develops 1,600,000 pounds of force.

Components mounted in a sabot in the barrel are accelerated by adiabatic expansion of a fixed volume of high-pressure air. After the acceleration pulse, the test component in the sabot is then decelerated as it travels down the length of the gun tube, compressing the air ahead of it.

The recoil energy of the gun is absorbed by allowing the gun to roll up on tracks where the lifting of the gun weight of 160 tons absorbs the resultant energy. The gun may be further

used as a launching device by opening up one end of the tube and firing into targets ahead of it.

Still another shock device available at the laboratory is a 12-inch Hyge actuator mounted horizontally. This device can create a velocity change of the order of 300 feet a second, imparting to weapon components a one-half sine pulse with a height of 700 G's for 15 milliseconds. The Hyge actuator uses a 3,000-p.s.i. air supply to accelerate a carriage, upon which the test component is mounted, down a 40-foot track. Built into the carriage is a brake which decelerates the vehicle at a low level following the shock pulse.

Now in operation in the laboratory is an MB electrodynamic shaker capable of 25,000-pound peak force. The shaker is powered by a motor-generator set which provides a frequency range of from 5 to 500 cycles a second.

The unique feature of this system is a 48-inch-diameter auxiliary table mounted on rubber shear pads upon which a static weight of up to 10,000 pounds can be bolted. This table, which allows the vibration of complete systems, has proved such a valuable aid to the weapon designer that a second shaker of the same capacity is being added to operate from the same power supply.

THE impingement of acoustically transmitted vibrations upon weapons and their components will be investigated in a new acoustic testing facility now under construction. The facility will permit acoustical testing in the frequency range between 600 and 9,600 cycles a second, with sound pressure levels to 170 decibels (zero db re:0.0002-microbar). The levels are equivalent to those encountered in many full-scale operations.

The facility will consist of a reverberant chamber, a plane-wave tube, and an anechoic room. The reverberant chamber will have an approximate volume of 40 cubic feet for reverberant-sound-field testing of small components and major subassemblies. It will be driven by electrodynamic audio driver units. The plane-wave tube, to be 25 feet long, will have an inside diameter of 10 feet and will be used for modified free-field testing at extremely high sound pressure levels with the tube powered by air-modulated sound generators.

The anechoic room will be approximately 6 feet square and 6 feet high, and the sound power will be provided by the electrodynamic audio drivers.

The effects of acoustical energy upon components fall into two general categories. The first type is the reversible failure, characterized by those transient failures which exist only momentarily during conditions of high sound generation. Examples of reversible failures are: binding of moving parts, leaks in pressure joints, electrical contact chatter, and microphonics in vacuum tubes. A second effect is the irreversible failure, characterized by such conditions as weld breakage, panel rupture, tube element failure, and tube envelope failure.

Now under construction is a 5-megawatt, light-water-moderated, heterogeneous-type nuclear reactor, a large dry-irradiation room, and the necessary laboratory space for the preparation and postirradiation testing of samples. In addition, equipment for combining the environments of heat, cold, altitude, and vibration will be available.

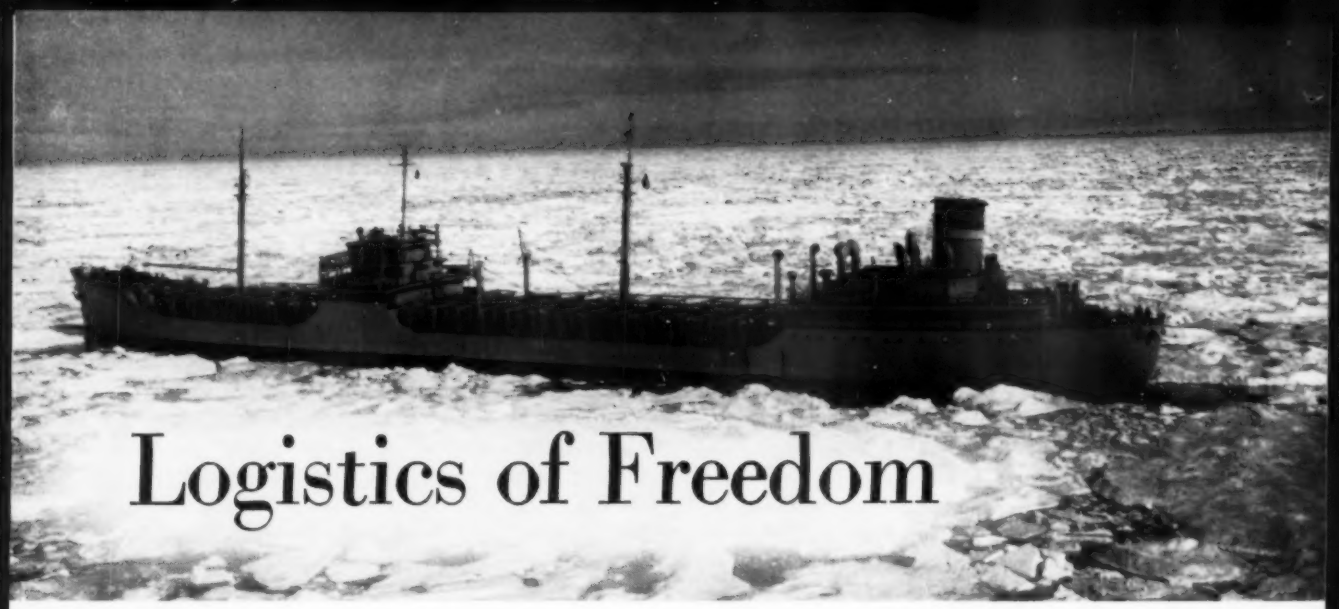
BECAUSE the facility will be operated twenty-four hours a day, seven days a week, the reactor facility is being designed to permit remote handling of items under test. Materials will be moved in and out of the irradiation room while the reactor is operating.

In the postirradiation room, hot materials will be handled by means of a manned, electrically driven mobile handler. An operator inside the vehicle, shielded by 6½ inches of lead, will actuate mechanical arms to pick up and operate irradiated test samples.

Man's quest for speed is exposing new environments and extending others. Most of the names are not new: temperature, vibration, acceleration, shock, radiation. However, their range and severity and the methods of applying such environments to weapons and components are rapidly changing.

The swift pace of today's development engineering is fast closing the time gap between the discoveries of the research teams and the application of the development teams.

One of several shock test devices, the 26-inch air gun can exert 1,600,000 pounds' force and can test specimens weighing up to 2,000 pounds.



Logistics of Freedom

The Navy's Military Sea Transportation Service maintains a nucleus fleet to sealift personnel and cargo to meet defense requirements

Adm. John M. Will

Until his recent retirement, Admiral Will was commander of the Military Sea Transportation Service. He is now president of American Export Lines, Inc., New York, N. Y.

OUR sea transportation resources for limited war are presently considered to be adequate. However, the degree of promptness with which sealift responds in an emergency will have an important impact on the eventual outcome. A limited-war crisis could well become a race against time to evacuate nationals, to redeploy troops and equipment, or to augment and resupply existing forces overseas. To be prepared for such situations, we must rely on the ready availability of modern merchant ships of all types.

The Navy's Military Sea Transportation Service was established in October 1949 to meet such eventualities. Its mission is threefold: (1) To provide sea transportation for personnel and cargoes of the Department of Defense; (2) To plan and negotiate for use of commercial shipping to augment the MSTS fleet as necessary to meet total requirements; and (3) To plan for and be capable of expansion in time of war as directed.

MSTS had its first opportunity to fulfill all three missions just nine months after its creation by a charter issued by the Secretary of Defense, placing under one authority the control, operation, and administration of sea transportation for personnel and cargo of the Department of Defense (excluding that transported by units of the Fleet).

The first test came with the start of the Korean conflict, and the newly formed ocean transportation agency clearly demonstrated its ability to perform its missions under fire. During the hostilities, MSTS sealifted over 54 million measurement tons of cargo, nearly 5 million passengers, and over 22 million long tons of petroleum products to the Far East.

Korea was not the final test in MSTS' short history. Nearly without warning, 300,000 Vietnamese chose to leave their homeland by sealift exodus in order to avoid life under Communism. Just as spontaneous was an uprising on the other side of the world, where thousands of Hungarian refugees were sealifted to freedom in America and elsewhere on MSTS-operated ships.

When the Suez Canal crisis erupted in 1956, MSTS assisted in the evacuation of our nationals from the threatened areas and subsequently, because of the closing of the Canal, undertook the rapid augmentation of the MSTS tanker fleet by the activation of some sixty tankers. This left commercial tankers entirely free to care for the petroleum needs of our own and our allies' civilian economies. The pattern repeated itself in last year's Lebanon crisis.

EVEN the normal operations of MSTS would hardly be considered routine. The job of delivering defense materials to the Arctic Distant Early Warning radar network, stretching now from the Aleutians to the east coast of Greenland, is an annual mission. Other tasks include participation in the Navy's Operation Deepfreeze in the

Antarctic; down-range sealift in support of Air Force missile tests and resupply of the Air Force radar warning stations off the New England coast; sealift of United Nations' troops; and assisting in the study of weather, currents, and waves—the latter activity alone resulting in a saving to MSTS, through rerouting of ships on the basis of wave forecasts, of $1½ million in the first year and a half.

BETWEEN "flare-ups," MSTS maintains its readiness with its nucleus fleet. This consists of Navy-owned ships classed as "in commission" or "in service." Commissioned ships—prefixed by U.S.S.—are ships of the U. S. Atlantic or Pacific Fleets assigned to MSTS and manned by U. S. Navy officers and men. In-service ships—prefixed by U.S.N.S.—are operated by MSTS and manned by civil-service marine employees or the operator's Merchant Marine personnel.

The number of ships in the nucleus fleet presently stands at 150. More than half of this fleet is made up of fairly small craft, including strictly amphibious and special-purpose ships having few, if any, counterparts in commercial operation. Many of them operate in the Far East, while others serve in the Pacific islands and Arctic regions, landing and picking up their cargoes by beachings at remote points usually inaccessible to the conventional type of commercial carrier.

To take up the slack between the capabilities of the nucleus fleet and the requirements of the shipper services (Army, Navy, Air Force), MSTS utilizes ships of the U. S. Merchant Marine under space, time, voyage, or bareboat charters, or requests the Maritime Administration to provide Government-owned ships from its reserve fleet. The Government ships are operated for MSTS by commercial shipping companies under general agency agreement.

In this connection, an agreement between the Departments of Defense and Commerce directs that all merchant shipping capability required in addition to that provided by the MSTS nucleus fleet will be obtained (consistent with military requirements and prudent management) in the following order of priority:

1. Maximum utilization of available U. S.-flag berth space.

2. Time or voyage charter of suitable privately owned U. S.-flag merchant ships voluntarily made available by industry. Such charters will be kept to the minimum necessary to meet requirements which foresight indicates cannot be met by U. S.-flag berth operators.

3. Shipping provided by the National Shipping Authority under general agency agreement.

4. Where U. S.-flag shipping is not available, MSTS may employ foreign-flag shipping to meet urgent military requirements.

THIS is in keeping with the Merchant Marine Act of 1936 which outlines our national shipping policy. This act declares it to be "necessary for the national defense and development of . . . foreign commerce . . . (to) have a Merchant Marine . . . capable of serving as a naval and military auxiliary in time of war . . . owned and operated by citizens of the United States in so far as may be practicable. . . . It is declared to be the policy of the United States to foster and encourage the maintenance of such a Merchant Marine."

In carrying out this phase of its mission, MSTS in 1958, for example, incurred operating expenses of $425 million, of which 78 per cent went to the maritime industry. Recipients included berth-line operators, tramp-ship operators, commercial operators of Government-owned ships, and private ship-repair yards.

MSTS was responsible for the transportation of 13.5 million measurement tons of cargo in 1958. Commercial ships accounted for 73 per cent of the 51 billion measurement ton-miles accomplished in the performance of this cargo lift. Berth-line operators, under shipping contracts and negotiated berth

Transporting troops is a major MSTS job (Army photo).

Crane boarding an LST during MSTS operations (Navy photo).

rates, carried the lion's share of the commercial lift.

Time-chartered and NSA-agreement dry-cargo ships numbered twelve at the beginning of the year, increased to a peak of thirty-four during July, resulting from the Mideast crisis, and then dropped to fourteen by year's end.

Over half of the 605,000 passengers transported in 1958 were enlisted military personnel traveling in troop accommodations. Commercial passenger ships were utilized over four principal passenger routes (Europe, Mediterranean, Hawaii, and the Far East) for cabin passengers beyond the cabin capability of MSTS transports.

During MSTS 1958 operations, 133 million barrels of petroleum and related products were transported. During August 1958 the highest lift of bulk petroleum made in any one month in MSTS history was accomplished.

Total lifts from its organization in October 1949 through fiscal 1958 show that MSTS had transported 13.4 million passengers, 165.6 million measurement tons of cargo, and 954 million barrels of petroleum products.

However, the MSTS story is perhaps most graphically told in terms of the intangible. The Military Sea Transportation Service is a worldwide laboratory where experiments in ocean transportation can be studied under the microscopes of the entire American Merchant Marine.

THIS laboratory has seen new concepts in ship design, new approaches to safety practices ashore and afloat, the exploration and development of remote operating areas, and many other departures from the routine and the ordinary put to practical use.

Many of these experiments have proved or will prove valuable to commercial shipping. Some, on the other hand, are too specialized for ordinary commercial requirements. The Military Sea Transportation Service, for example, has led the way in the field of Arctic operations. In resupplying the Arctic Distant Early Warning (DEW) Line, the key link to the Northwest Passage (Bellot Strait) was proved to be safe for use by deep-draft ships.

MSTS, concerned with ice damage to conventional ships, conceived the prototype ice-strengthened small tankers and cargo ships which are now helping supply the American bases in the Far North.

When the Maritime Administration converted two conventional Liberty ships to gas-turbine and free-piston propulsion, MSTS operated them to prove their reliability and practicability. It is obviously the role of the Government to underwrite costly experiments of this nature, and the ventures are paying off. Both ships have logged impressive sea miles, and their performance is being studied for possible adaptation in upcoming new construction.

Probably the most dramatic example of prototype design is the U.S.N.S. COMET, the roll-on, roll-off ship. Her performance and her capabilities were disclosed recently to commercial operators at a conference in Washington at which American-flag shipowners were urged to consider vessels of this type in their replacement construction programs.

That MSTS has initiated conferences of this nature and has consistently called upon private industry to gear its future construction in terms of fast, modern transports, roll-on, roll-off ships, and heavy-lift vessels is further proof that MSTS plays the dual role of laboratory and technical adviser and consultant to the industry.

Recently the roll-on, roll-off ship U.S.N.S. TAURUS was added to the fleet to supplement the COMET.

"The Military Sea Transportation Service is a worldwide laboratory where experiments in ocean transportation can be studied under the microscopes of the entire American Merchant Marine.

"This laboratory has seen new concepts in ship design, new approaches to safety practices ashore and afloat, the exploration and development of remote operating areas, and many other departures from the routine and the ordinary put to practical use."

Ships of MSTS have led the way in the field of safety and have set patterns that the commercial operators have followed.

Fire-fighting and damage-control instruction are regular features aboard MSTS ships. Both licensed and unlicensed crew members have attended these schools ashore and received instruction aboard their ships during in-port layovers. The strong emphasis upon safety in all departments has resulted in fleet-wide adaptation of employee suggestions and probably has made MSTS personnel more safety-conscious than those in any other ocean transportation agency anywhere.

Without a healthy American commercial maritime industry, MSTS would be greatly handicapped in fulfilling its missions in peace and war; hence its efforts to utilize private industry's resources wherever possible.

AS it is with ships, so with men. In this high-speed, nuclear-rocket-missile age, there will not be time to train the executives an emergency would require. Like the Minutemen of Revolutionary days, who wore no special uniforms either, fifteen leaders in the commercial ocean transportation field met recently at the Washington headquarters of the Military Sea Transportation Service for their first training session as MSTS Executive Reservists.

Preparing to fill civilian positions in the areas of ocean transportation, manpower, ship conversion, repair, and material procurement in case of a national emergency, they underscore MSTS' determination to maintain a state of readiness for war while fulfilling its peacetime mission.

Selected from industry on the basis of experience and executive ability, they form the MSTS unit of the National Defense Executive Reserve inaugurated by President Eisenhower in 1956 as a preparedness measure. By attending training meetings and defense exercises regularly each year—incidentally, without compensation—they will be ready to step into their prearranged MSTS roles at once in the event of full mobilization.

Ordnance for the New Army

The M60, the Army's new main battle tank

An account of the Association's 41st Annual Meeting at Aberdeen

MORE than 5,000 members of the American Ordnance Association gathered at Aberdeen Proving Ground, Md., on Thursday, October 8th, to celebrate Ordnance Day 1959 by witnessing tests and demonstrations of the firepower and fighting equipment of "The Army of the Future" that marked this Forty-first Annual Meeting of the A.O.A. Included in the demonstration of nearly fifty items of new and future weapons were nine that were shown to the public for the first time.

The members were welcomed to the Proving Ground by Maj. Gen. H. N. Toftoy, Aberdeen commander, and also were greeted by Lieut. Gen. J. H. Hinrichs, Chief of Army Ordnance; Gen. Lyman L. Lemnitzer, Army Chief of Staff; and the Hon. Wilber M. Brucker, Secretary of the Army. A.O.A. President Louis Polk replied to these greetings, and the demonstrations began with a parade of the Army's missiles, including the Hawk, Nike Hercules, Lacrosse, Corporal, and Sergeant.

During the parade a march entitled "Mister Guided Missile" was played publicly for the first time by the 324th Army Band directed by CWO Anthony Bacca who composed the piece in tribute to General Toftoy.

There followed demonstrations of rifles and automatic weapons ranging from the Army's 1903 Gatling gun, through the newly adopted 7.62-mm. M14 rifle and M60 machine gun, to the multibarreled 20-mm. M61 aircraft weapon which can fire at the rate of 6,000 rounds a minute.

Among the weapons shown for the first time were the lightweight 4.2-inch mortar T201 and the 90-mm. medium assault weapon (Maw) designed to provide the infantryman with a shoulder-fired piece that can penetrate all existing armored vehicles.

Five artillery weapons also were shown for the first time. These were improved towed versions of the 105-mm. and 155-mm. howitzers, the 115-mm. "Moritzer"—a close-support weapon using the boosted-rocket principle—and new self-propelled 105-mm. and 155-mm. howitzers. The 105-mm. howitzer T195 is an amphibious close-in artillery support weapon and is air-transportable due to its all-aluminum armored hull. The 155 also features aluminum plate, is amphibious, and with its new diesel engine and longer-range ammunition has greater effectiveness than its predecessors.

During the noon hour an appetizing box luncheon of fried chicken and all the trimmings was served, and members also took advantage of this time to inspect the many interesting static exhibits which showed latest equipment and developments of the Army technical services as well as of the Ordnance arsenals and laboratories.

THE afternoon session opened with a thrilling airborne operation by Company C, 501st Battle Group, 82nd Airborne Division. A 106-mm. jeep-mounted recoilless antitank weapon was dropped by parachute from a C-119 to

(*Continued on p. 408*)

Above, the "Maw," a shoulder-fired, 90-mm. recoilless rifle firing a shaped charge with an effective range of 500 yards—more than twice that of the bazooka—and capable of destroying the heaviest known tanks. Right, viewing the Aberdeen demonstration, left to right, Maj. Gen. P. L. Freeman, Commanding, the Infantry Center, Ft. Benning, Ga.; Lieut. Gen. J. H. Hinrichs, Chief of Army Ordnance; Gen. B. C. Clarke, Commanding, Continental Army Command; Secretary of the Army Wilber M. Brucker; Maj. Gen. H. N. Toftoy, Aberdeen Proving Ground commander. Directly behind General Hinrichs is Louis Polk, A.O.A. president (Army photos).

Left, demonstrating the air mobility available for Army firepower, an Army Vertol 107 helicopter lands crew and entire Little John rocket system. After rapid emplacing and firing, crew and equipment are then picked up by same helicopter for redeployment elsewhere (Army photo).

Above, right, the "Moritzer," a combination mortar and howitzer utilizing the best features of both. A 115-mm. field artillery weapon, it possesses the light weight and high rate of fire of a rocket launcher plus the precision of an artillery piece. Center, right, mobility and ease of handling the new Sergeant missile were dramatically demonstrated as crew emplaced and fired missile within twelve minutes' time. Below, left, operational today, the free-flight Honest John surface-to-surface artillery rocket travels on its own self-propelled launcher. Below, right, the 8-inch, unarmored, self-propelled howitzer T236 is air-transportable and designed for use as general artillery and for close-in support of armor (Army photos).

Above, section of Aberdeen viewing stands crowded with A.O.A. members. Below, General Hinrichs holds first production model of the M14 rifle which Secretary Brucker, right, presented to Sgt. Maj. G. C. Ferguson of the Infantry Center, Ft. Benning, Ga.

Below, the Army Transportation Corps' new rolling fuel transporter (Army photos).

land gently right in front of the gaping audience. The paratroopers followed in short order and soon drove the jeep to a prepared position and fired the weapon. Pfc. G. D. Spivey also made an accuracy jump from a helicopter hovering high over the stands, and landed within ten feet of the onlookers.

Demonstration of a Chemical Corps flame-throwing tank followed, to be succeeded by showings of new Army trucks ranging from the new lightweight jeep M151 through the 8-wheeled, 2½-ton, XM410 and including the Mechanical Mule, the 1-ton, 8x8, XM384, and the multifuel 2½-ton, 6x6, M35E7.

In an impressive demonstration of rocket artillery, the 318-mm. Little John rocket XM47 was landed by helicopter, emplaced, and fired—all in just a few minutes—showing the mobile firepower of this weapon. The long-range 762-mm. Honest John M31 rocket also was fired as was the 4.5-inch multiple rocket launcher.

FIVE special-purpose vehicles were then demonstrated. These were: (1) The "Superduck" XM147E2—an amphibious, 2½-ton, 6x6, vehicle that replaces the famous World War II DUKW; (2) The 54-ton recovery vehicle M88, capable of towing the heaviest Army tank; (3) The new aluminum-armored personnel carrier M113, air-transportable, fully amphibious, and capable of carrying 13 men; (4) The 25-ton semitrailer XM173E1 with powered rear axle for increasing off-road mobility; and (5) The new 15-ton, 8x8, tractor truck XM194E4 with a 60-ton-capacity semitrailer.

Of special interest was the first showing of the Army's FASS (free air suspension system) vehicle being developed by the Ordnance Tank-Automotive Command. This vehicle employs the ground-cushion phenomenon and typifies a mode of air suspension utilizing a peripheral jet to contain air under the base of the vehicle.

The concluding demonstration of tank firepower was marked by the spectacularly accurate shooting that has distinguished this event on Ordnance Day through the years. The light 76-mm. gun tank M41 and the heavy 120-mm. gun tank M103 both showed

their ability to deliver rounds on target rapidly and accurately.

The 90-mm. gun tank M48A2 was demonstrated equipped with an experimental ballistic computer XM16 which is designed to introduce into the sights corrections for drift of the projectile, jump, parallax between gun tube and sights, muzzle-velocity loss due to tube erosion, and cant of the vehicle. The information for these corrections is fed into the computer continuously from a coincidence-type range finder. A similar tank, the M48A1, equipped with a stabilizer, showed the ability of the tank gun to stay on target while the vehicle moved over uneven terrain.

Of particular interest was the new M60, known as the main battle tank, armed with a high-velocity 105-mm. gun and powered with a 750-horsepower compression-ignition engine. It is scheduled for production in April to replace the present Patton 48 tank.

A high spot of the program was the presentation of the very first production model of the Army's new M14 rifle—No. 0001—to Sgt. Maj. George C. Ferguson who was wounded eight times in World War II fighting. The presentation was made by Secretary Brucker. Now assigned to the Army's Advanced Marksmanship Unit, Fort Benning, Ga., Sergeant Ferguson was decorated for his heroic exploits while serving in Europe with the 378th Infantry Regiment of the 95th Infantry Division.

This simple ceremony of presenting an outstanding weapon to an outstanding soldier underscored in dramatic fashion the real purpose of the Industry-Ordnance Team—the development of the best possible weapons so that our fighting men will have them in quantity whenever needed for the defense of America. For this purpose the Ordnance Association was founded forty years ago; to this ideal its 43,000 members are dedicated.

The day-long tests and demonstrations at Aberdeen on October 8th proved without doubt that Army Ordnance is well aware of its obligation to the fighting man and is leaving no stone unturned to develop for him the most advanced and effective weapons that time and available money can provide.

Above, Col. Walter T. Kerwin, distinguished World War II artillerist, stands beside the new 155-mm. howitzer. Below, parade of missiles at Aberdeen (Army photos).

Below, the Scorpion 90-mm. self-propelled gun M56, is highly maneuverable and light enough to be transported in large cargo aircraft and air-dropped (Army photo).

Single-standard Problems

The ideal of a single standard for all the weapons of the armed services of all the Western powers seems very desirable, but there are many practical road blocks that make its attainment difficult

Lieut. Col. Melvin M. Johnson, Jr.

ALL musketmen should have the same musket, type of ball, powder, powder charge, and ignition system. This is the logistic ideal. One weapon must do everything but cook; even that.

All allies should have the same standard weapons, equipment, vehicles, and supplies. This is an ideal also.

In 1938 the Nazi army was regarded as ideal because, due to the Versailles Treaty, which the Nazis chose not to read, their army had not only all new but strictly single-standard small arms. Our then Chief of Staff publicly acknowledged U. S. Army envy of the Nazi's single standards.

The German Nazi record from 1939 to 1945 discloses, however, a wide variety of weapon models. As with the United States in 1861-1864, in 1898, in 1917-1918, and in 1941-1945, an amazing array of "nonstandard" weapons found their way into the tables of German World War II equipment.

Invention reared its ugly head. Development and necessity combined to confound single standards, and the Nazis ended up with 3 rifle types, 3 machine carbines of 2 different calibers, 2 types of machine guns (MG34, MG42), and a total of 3 small-arms calibers.

Granting the undoubted virtues and advantages of uniform single-standard weapons and equipment, there are five major road blocks to this ideal based upon bitter U. S. experience in two World Wars and in Korea.

Colonel Johnson, U.S.A.R., Inactive, inventor of the Johnson semiautomatic rifle, is an authority on small arms. He is currently serving as a research consultant, New Haven, Conn.

1. *The Same Service Problem.*—Despite the purest military imposition of command decision, the modern record shows many examples of intraservice and intrabranch splits over requirements and characteristics. It would be as silly to state, for example, that in the Army the Office of the Chief of Staff, CONARC, and the Ordnance Corps never encounter disagreement over what's to be next in new weapons, as it would be to say that all concerned do not strive mightily and faithfully toward absolute accord.

For example, the competitive merits of the new M14 (then T44) rifle versus the Belgian FN-T48 rifle were the subject of considerable intra-Army debate, though far outshadowed by Navy and Air Force intraservice disagreements over missiles and countless other items.

2. *The Interservice Problem.*—There are many weapon and equipment areas which should logically offer common standard items for all the services. However, just as within a single service one branch's meat may be another's poison, so also, for example, the characteristics of carrier-based aircraft differ from those of land-based types. Because some Navy and Air Force targets differ, aircraft armament requirements must be different.

The extent and intensity of single-standard interservice arguments over missiles is far beyond the scope of this soliloquy. There are not many missiles which have escaped interservice debate as to standards, quite above and beyond the question of which service shall operate missile M-XYZ, M-ABC, and so forth.

3. *The NATO Problem.*—This problem is a far greater road block than the interservice one. It is in effect more of the same, but tremendously amplified. The pure, clear, practical logic which supports NATO single standards as a means to conquer logistic chaos is as unassailable as are the multifaceted NATO-nation facts of life which so emphatically enervate such endeavors.

For example, the strategy, the probable missions, terrain, anticipated scope of total military effort, size of maximum forces, capacity to produce or procure outside, basic tactical doctrine, degree of probable training, type and character of personnel, national pride and pride of "authorship," concern over dependence upon others for weapons—all these and many other factors

distinctly tend to defer, if not defeat, many significant single-standard solutions in NATO.

Since the U.S.A. is continually "picking up the tab," it might be well if all NATO took U. S. standard weapons and equipment with no exceptions. But might not such a policy damage the scope of NATO development versus the Soviets?

After very extended arguments, NATO has agreed to the U. S. T65E3 cartridge as the 7.62-mm. NATO round. Shorter (2.80 inches) in over-all length than any of the established NATO rounds, the new cartridge can be fitted into existing NATO small arms and is standard for the FN and U. S. M14 rifles and the U. S. M60 machine gun.

West Germany, however, logically has gone back to the German MG42 (1942) machine gun but in 7.62-mm. NATO caliber—the MG42 being only slightly heavier but somewhat simpler than the M60 and much easier for West Germany to produce.

NATO standardized the 9-mm. Luger round for pistols and submachine guns. But the U. S. has decided to retain the M1911 caliber .45 pistol and discontinue submachine guns. All of which are mere surface-scratching examples of the NATO standardization problem.

4. *The Development-Production Problem.*—The fourth road block stems from the fact that in the United States the armed services dominate armament development for the most part. Off-the-shelf weapons privately developed and produced are very rare exceptions to prove the rule. However, each service subscribes to somewhat different practices, even in some cases different within one service for reasons attributable to a particular type of "beast."

Contemplate the lists of "misguided" missiles, for example. There are hardly enough Greek gods to supply names for them all. Again, there are much worse complications when NATO is included. Even if NATO nations abroad wanted to adopt some of our superweapons they would have trouble finding out just what we propose to standardize.

Many reasonably intelligent and informed authorities both here and abroad are deeply concerned lest all of NATO lose the benefit and strength which comes from put-to-practice ideas, of whatever nationality. If NATO is to have its full strength, research and development cannot be put under virtual martial law or executive fiat.

Beyond research and development come engineering and production. American mass-manufacturing techniques are somewhat different from the British, and quite far apart from those of most of Europe.

5. *The Rapidly Rising Cyclical Curve.*—Afficionados of charts and curves would be hard put to portray the comparative up-jump of military research and development during the past fifteen years. Much of this astral ascent comes from long-past basic and applied research, now suddenly coming to fruition. Almost every week, sometimes daily, surprising and deadly development-stage weapons are disclosed.

Exciting, exotic, and sophisticated as many seem to sound, such weapons and equipment inevitably drive even pragmatic single-standard logisticians to aspirin antidotes. What is standardized today appears to have been obsolete yesterday and obsolescent the day before.

Is it possible we are straying so far from the practical necessities of standardization that when we start some new items we don't know where we're going; that when we reach what seems a solution we're not sure we can apply it?

To set the ideal of frozen single standards ahead of inevitable inquiry and intensified research and development seems as foolish as to propose fighting imminent war with carbon-copy formulae, starry-eyed sketch prints, or first-model prototypes.

World War II was notable as a period of mass production in which America clobbered her enemies with weapon volume, but the present and foreseeable future inescapably stresses research, high-speed development, and energetic engineering. Whereas full mass production permits a single-standard freeze, development demands some degree of multistandard flexibility. Otherwise we should stay standardized on 1936 M1 rifles, 1917 Brownings, pre-World War II howitzers, and so forth, and we should standardize at once on just one IRBM, one ICBM, and choose between liquid and solid propellants.

In view of both demands upon us—one to keep ahead in new weapons, the other to have standardized equipment on hand with which to fight on call—we must balance the "whiz-boom" with basic needs. No one can stop the current cyclical up-curve, and should not even if possible. But there also must be some foundation, proven and ready at all times.

In summary, the foreseeable future, as with the present, is an era not consonant with strict single-standard concepts. Spawned from essential basic and applied research, in deference to the need for fewest standards no new weapon should be developed unless it offers real promise of ultimate, finalized performance significantly superior to existing weapons, or unless it can fulfill new functions and missions. "Fringe" advances should be frowned upon.

Judgment should be exercised throughout by the customer, in this case the using branch, not by a supply branch or corps of a service. The user instinctively wants the best and fewest standards. The Secretary of Defense is of course the court of last resort.

Though against the single-standard concept, it is essential with our advanced weapons to have "two strings to the bow." Ancient archers carried two strings, lest one be all wet—a point not to be lost now. Trial standard items are the only practical meeting ground between the single-standard ideal and our current "supersonic" situation.

In a period of peace we must develop for D-day. Should future war be waged for merely a matter of months, all the more reason for springing to arms with the greatest array of the most advanced armament available. This situation should outweigh past insistence upon the supersanctity of the single standard —logistically ideal though such a standard would be.

Our Defense Posture

Program of the Association's Annual Industrial Preparedness Meeting

The Forty-first Annual Industrial Preparedness Meeting of the American Ordnance Association will be held on Wednesday, December 2, 1959, at the Waldorf-Astoria Hotel, New York City. There will be morning and afternoon seminars on America's Future Weapons Needs and the Task of the Industry-Ordnance Team. There also will be the annual Armament Preparedness Luncheon, and the Industrial Preparedness Dinner. Louis Polk, A.O.A. President, and Henry N. Marsh, A.O.A. Vice-President, will preside at the seminars. The program follows.

Morning Session—9:30 o'clock—Starlight Roof

SEMINAR: AMERICA'S FUTURE WEAPONS NEEDS

CHAIRMAN

LOUIS POLK

President, American Ordnance Association; President, The Sheffield Corporation, Dayton, Ohio; Vice-President, Bendix Aviation Corporation, Detroit

SPEAKERS

LIEUT. GEN. ROBERT F. SINK

Commanding General, XVIII Airborne Corps, United States Army, Fort Bragg, N. C.

VICE. ADM. WILLIAM R. SMEDBERG, III

Commander, Second Fleet, United States Navy

LIEUT. GEN. ROBERT M. LEE

Vice Commander, Air Defense Command, United States Air Force, Ent Air Force Base, Colorado Springs, Colo.

Midday Session—12:30 o'clock—Starlight Roof

ARMAMENT PREPAREDNESS LUNCHEON

PRESIDING

LIEUT. GEN. LESLIE R. GROVES

President, New York Post, American Ordnance Association; Vice-President, Remington Rand Division, Sperry Rand Corporation, Stamford, Conn.

ADDRESS

DR. HOWARD A. WILCOX

Deputy Director, Research and Engineering, Department of Defense, Washington, D. C.

Afternoon Session—2:45 o'clock—Starlight Roof

SEMINAR: THE TASK OF THE INDUSTRY-ORDNANCE TEAM

CHAIRMAN

HENRY N. MARSH

Vice-President for Technical Divisions and Sections, American Ordnance Association, Wilmington, Del.

SPEAKERS

LIEUT. GEN. JOHN H. HINRICHS

Chief of Ordnance, United States Army, Washington, D. C.

REAR ADM. PAUL D. STROOP

Chief of the Bureau of Naval Weapons, United States Navy, Washington, D. C

LIEUT. GEN. ROSCOE C. WILSON

Deputy Chief of Staff, Development, United States Air Force, Washington, D. C

Evening Session—7:30 o'clock—Grand Ballroom

(Reception—6:30 o'clock—East Foyer)

INDUSTRIAL PREPAREDNESS DINNER

PRESIDING

LIEUT. GEN. LESLIE R. GROVES

President, New York Post, American Ordnance Association; Vice-President, Remington Rand Division, Sperry Rand Corporation, Stamford, Conn.

TOASTMASTER

LOUIS POLK

President, American Ordnance Association; President, The Sheffield Corporation, Dayton, Ohio; Vice-President, Bendix Aviation Corporation, Detroit, Mich.

AWARD OF THE WILLIAMS GOLD MEDAL TO

HON. HENRY CABOT LODGE

The Representative of the United States of America to the United Nations

ADDRESS

HON. HENRY CABOT LODGE

(Reservations close on Monday, November 16, 1959)

(Air Force photo)

The Mace Missile

Maj. Gen. Daniel W. Jenkins

THE first tactical surface-to-surface guided missile, the TM61 Matador, developed for the Air Force by the Martin Company, went into operational service in 1953, months before other more spectacular missiles were unveiled to the public.

Today, Tactical Air Command's second tactical missile, the TM76A Mace, is ready for use by operational units. An outgrowth of the Matador, the Mace is designed to penetrate any known enemy air defenses and to deliver nuclear or conventional weapons against tactical targets during day or night and under all weather conditions.

As its name, tactical missile, implies, the Mace, which is now replacing the Matador, is not an ICBM. It is a missile of relatively short range, powered by a single Allison J33-A-41 turbojet engine rated at 5,200 pounds' thrust and long-proved by use in manned fighter-type aircraft. A booster rocket, generating 100,000 pounds of thrust, is used in the initial blast-off.

The Mace was built to complement tactical fighter-bombers in their mission of counter air operations and air interdiction.

General Jenkins is deputy commander, Ninth Air Force, Shaw Air Force Base, S. C.

To the enemy, interdiction means knocked-out supply depots, demolished rail centers, and craterized roadbeds. In short, air interdiction denies the enemy the means with which to fight by destroying a great portion of his capability before it can be brought to bear and by undermining the will of his troops to fight.

With the acquisition of the Mace, the Air Force now has a much-improved 24-hour all-weather interdiction capability. This versatile missile can fly at very low altitudes, skipping along the contours of the earth, avoiding detection by radar.

Its all-weather capability gives us the means for destroying marshaling yards, hidden from a pilot's view by low ceilings, and weathered-in bombers and fighters at their home base. Unlike the fighter-bombers, the Mace can be launched in a raging snow storm, and, without the aid of radar or other ground control devices, seek out and destroy enemy targets.

Although our jet fighters continue to play an impressive role in air interdiction, their operations are necessarily affected by weather and depend on ground navigational assistance.

Operating in either favorable or adverse weather, the Mace's self-contained navigational system even provides a means for varying its attack routes. It can skirt mountains and can change its altitude to follow the ground's contour.

Called ATRAN (Automatic Terrain Recognition and Navigation System) this navigational guidance system built by Goodyear Aircraft Corporation provides automatic terrain guidance features by comparing the terrain over which the Mace is flying with a film strip of the programmed route, produced from topographical maps.

If the missile's flight path deviates from the programmed path on the film map, the system adjusts to the required correction. ATRAN is virtually impossible to jam by means of electronic countermeasures.

Therefore with prepared data on enemy terrain characteristics we can select any route to the target. This increases the element of surprise and burdens the enemy with additional complications in air defense against the Mace.

Fewer than ten TAC crewmen are required to handle and launch several Mace missiles. Because the missiles utilize a standard aircraft-type jet fuel, no special handling or storage problems are involved, and the Mace can be kept in constant readiness for launching.

Vulnerability of our Mace weapon system is greatly decreased by its mobility. Its launching pad is actually the bed of a specially built trailer, called a Translauncher, towed by a Teracruzer.

The Teracruzer, or MM1 unit, has a flat open bed for carrying various equipment packs such as those needed for ordnance, assembly checkout, and launching. Both units ride on huge barrellike rubber tires at speeds up to 40 miles an hour through all types of weather and over seemingly impassable terrain.

THIS makes it possible to move the Mace rapidly into the area most needed or, by moving at irregular intervals, making the enemy's problem of ferreting out the weapon's exact location extremely difficult.

From one theater of operations to another, an operational Mace unit can easily be carried by C-124 or C-130 aircraft.

The Mace's retaliatory power in the face of a would-be aggressor is a prime deterrent to hostile operations. Very soon this deterrent power will be in place in Europe where Matadors now stand facing a powerful missile, fighter, and bomber force in Russian satellite countries.

As additional Mace weapons roll off the assembly lines, it is reasonable to assume that Matador units in Korea and Taiwan will be converted to the newer missile.

The Mace was for several weeks recently the center of attention of Congressional and military leaders in Washington. Although Congress initially cut off funds for production of new "B" model inertially guided Mace missiles, the Air Force was joined by the Secretary of Defense, the commander in chief of NATO forces, and the commander in chief of the Pacific Air Forces in successfully requesting restoration of funds to be available for the new program in the 1960 military budget.

A thousand or more of our Mace technicians will soon complete their training at the Tactical Air Command's Missile School, Orlando Air Force Base, Fla.

Training at the school, which is conducted by Ninth Air Force's 4504th Missile Training Wing, has been increased by nearly fifty per cent this year.

Flight test training for Mace missilemen with the new inertially guided TM76B missiles will soon move from Holloman AFB, N. Mex., to the Atlantic Missile Test Center in Florida where the TM76B's longer range (over 1,200 nautical miles) can be fully and safely tested.

By virtue of the Mace's simplicity, and our experience with the airframe and propulsion system since 1953, training of personnel on the new weapons system is a relatively easy task. It is only a matter of up-grading or modernizing our Matador curriculum to fit this newest of tactical missiles.

Initially, an airman selected to become a member of a Mace unit attends a short course in the fundamentals of electronics after which he is enrolled in the Mace school.

He trains with his own team and stays with it permanently. From Orlando, Mace teams are sent to launching ranges at Holloman AFB, N. Mex., for an actual test launch and from there to an overseas area where they become members of strategically located operational units.

AT Holloman, the Mace teams will get a glimpse of a new version of the Mace, the TM76B, currently being test-flown there. The TM76B is guided by an inertial guidance system built by AC Spark Plug Division of GMC. This system is a form of "memory navigation" which records the distance traveled by the missile and the precise directions of every movement it has made. In this way the inertial unit "knows" where the missile is at every moment in relation to the launch base and the target. Target information is preset into the system prior to launch, and the missile is then guided throughout its course.

Types of missiles, just like types of aircraft, become outdated when technical knowledge increases. As technical break-throughs give us better weapons, there will be an immediate and corresponding refinement in the art and science of tactical warfare.

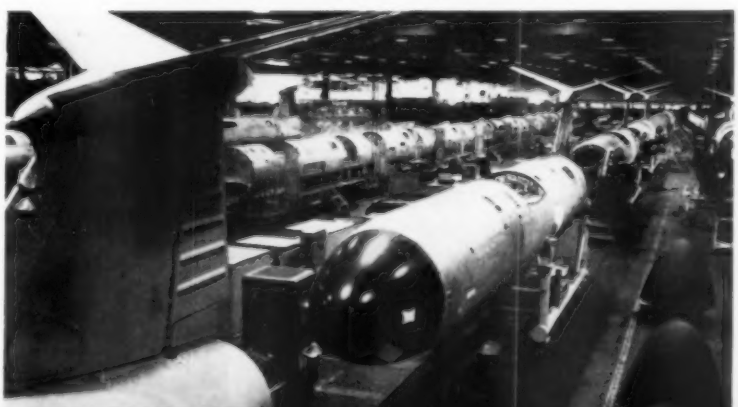
Altogether, the Mace offers us the following tactical advantages:

1. This missile can be dispersed as a completely self-contained, independent unit. This gives it survivability.

2. It is probably the least complicated missile in our inventory today, and, by virtue of this simplicity and our experience with the airframe and propulsion system, it also is probably the most reliable.

3. This system gives us a penetration ability of a very high order since it moves under radar defenses, day or night, and in any kind of weather.

TM76 Mace missiles roll off the production line.



Modern Fuzes

These amazing devices for detonating projectiles have a built-in intelligence which enables them to detect their nearness to a target by proximity, noise, heat, pressure, and other novel means

Robert L. Eichberg

THE modern military fuze is a remarkably accurate device that is designed to detonate a bomb, mine, shell, projectile, or missile at a definite time and place so as to do the maximum damage to its target. Although fuzes are used by the millions in combat, many people are unfamiliar with their function and versatility.

To some a fuze may be "something you light with a match when you're throwing a bomb," or "something that makes a projectile explode when it strikes the target," or even, "a clockwork that explodes a projectile after a certain period has elapsed."

These definitions are all true, but they do not give an accurate picture of what a fuze really is. It is like defining dogs as things that have four legs and bark—which is also a description of rustic furniture!

One type of fuze may locate its target by optical means, as when a target is close enough to throw a dark shadow across it. A photocell in the fuze recognizes the change in light intensity and sends an electrical signal to associated circuitry, causing the fuze to fire the main charge.

Just as a man has his five senses, a fuze may have one or more of several senses. Just as a man may listen for an enemy, a fuze may listen for the approach of a target. In a fuze of this sort, a microphone detects proximity to the target, usually by means of target-generated noise, and tells the fuze when to fire.

Mr. Eichberg, an ordnance engineer, Washington, D. C., is the author of a number of scientific papers.

The sense of touch also is employed by fuzes. An obvious example is the contact fuze which initiates burst when the missile strikes the target. Other examples are the fuze which detects vibration and is suited for use in antitank mines and the fuze that senses proximity to a heat source, such as a jet aircraft exhaust, much as a man would know when he was approaching a hot stove.

I know of no fuzes which employ the senses of taste and smell, but fuzes do have other senses which man does not possess. A fuze, for example, may include a miniature radio transmitter and receiver. A signal from the transmitter is reflected from the target, and the reflected wave is picked up by the receiver. When the transmitted and the received signals are mixed, the resulting pulses trigger the fuze.

A fuze also may be designed to sense height above ground or water to burst a bomb most effectively against surface matériel, transport, or personnel. The radio principle or a barometric device can serve as an altimeter in such a fuze. For underwater burst at the desired depth, a pressure-sensitive device may be used.

The types of fuze actions mentioned above are merely basic examples. Fuzes, as actually produced, are far more sophisticated. A fuze must be completely safe for using troops. Thus it must be able to differentiate between the forces produced by launching or firing (which should arm the fuze) and those resulting from, say, a 40-foot drop onto concrete (which should leave the fuze unarmed). In other words, a fuze should "know" whether the projectile in which it is mounted is intentionally fired or whether it accidentally has been dropped out of a cargo net onto a pier.

ONE way in which this can be done is to design the safety-and-arming (S&A) system so that a continuing force, rather than a momentary one, is needed to arm the fuze. There are many ways in which this can be done. In one instance, a weight exerts force on a clock mechanism; if the force is not applied for a predetermined period, the S&A system resets to the unarmed condition.

Mechanical methods are by no means the only way in which a fuze can be armed. The safety system may be electrical, with a charge being injected into the fuze at the moment a bomb leaves the bomb bay. Time delay can be achieved by applying the electrical charge to a capacitor from which it is caused to leak through a resistor to a

second capacitor which, when charged, causes a breakdown in a circuit, permitting the second capacitor to discharge through an electrically actuated gas generator encased in a cylinder, the piston of which moves to arm the fuze.

Power supplies for electrically operated fuzes are extremely diverse. They may, as mentioned, consist of charged capacitors. They may be batteries of various types. They may be crystals which emit a pulse of electricity when subjected to shock, much like a phonograph pickup. They even may operate on the static generated by the flight of the projectile.

AN ordnance fuze, in short, is a highly sophisticated brain which prevents a projectile from firing until it is in a position which is safe for the users. It then arms the projectile, putting it in condition to fire when certain criteria are met. The fuze now surveys its environment, waiting for certain phenomena to be encountered. Meeting these phenomena—and under only one other condition—it causes the projectile to explode when in a position to inflict maximum damage on the target.

The other condition under which the fuze may cause burst is if the projectile has missed the target widely and is falling back to earth, perhaps onto friendly territory. In this event, the fuze will detonate and destroy the projectile before it can reach an area to which it would cause undesired harm. This action is known as self-destruct.

Fuzes must meet stringent requirements unlike those of household electronic devices, such as radio or television receivers. A commercial receiver is expected to operate day after day. If it fails, a repairman soon puts it to rights. A fuze must operate once and only once, but its functioning must be perfect. If the fuze fires the main charge too soon, it may destroy the personnel who have fired the round. If it functions too late or not at all, not only will the target go unharmed and so be able to complete its mission but the multithousand-dollar missile which carries the fuze will be wasted.

So special components and techniques have been devised for fuzing. If a pillow falls off a truck, it is less likely to burst open than is a sack of flour. The pillow is lighter, so has less inertia. Thus, fuze components are kept as light as possible, consistent with other requirements. Since the size of an object of a given material and configuration is a determinant of its weight, components are made as small as possible, subject to other requirements.

A small vacuum tube was once the size of the first joint of your little finger. It was reduced to the size of an eraser on a lead pencil. Transistors replaced tubes—they were the size of a small pea. Now transistors for fuzes are no larger than the period at the end of this sentence and are thinner than the paper on which this is printed.

Resistors in fuzes originally were about as big around as the stick of a lollipop and some half-inch or less in length. Now they are simply a small smear of resistive ink on a nonconductive plate. The same with capacitors: once looking like a half-inch or so of round lead pencil, they are now a couple of spots of conductive ink forming the "bread" of a sandwich in which the "meat" is a dielectric material. Resistors and capacitors are both printed on the nonconductive plate as are the wires connecting them into a circuit.

Such printed circuits are extremely rugged. The first electronic fuzes consisted of the earlier types of parts mentioned above, connected with wires.

In a later technique, the cavity containing the circuitry was filled with molten plastic. This held the circuit elements in fixed position when it had solidified, but its shrinkage when changing from the fluid to the solid form sometimes caused damage. Printed circuits need no such protection and are far cheaper to produce.

Fuzes might be said to form a race much like people, with the same spread in education and innate intelligence among groups and individuals. There is the extremely simple fuze which causes explosion when the projectile carrying it strikes a target—this might correspond to an Australian bushman. At the other end of the scale would be an extremely sophisticated fuze which might be likened to a foremost nuclear physicist.

Cutaway of an early proximity fuze used on World War II shells.

New Combat Aircraft

First official photograph of the Air Force's RB-57D Martin jet bomber, above, shows the new craft in formation with the smaller B-57B (rear). The new version will be used for high-altitude reconnaissance. The Air Force's newest long-range all-weather Republic F-105D, below, can carry a variety of armament including the A-bomb and the M61 "Gatling" machine gun.

Defense Highlights: Monthly Review and Outlook

• **Truce of the Bear.**—Let's not be deceived by any supposedly friendly overtures from the Communists. Their master plan calls for a prostrate slave world dominated completely by atheists.

And they're doing all right. In the thirteen short years since the close of World War II, the Communists have taken over 16 nations with a population of 800,000,000. They're still advancing on many fronts.

Stalin complained, at the close of the war, that his country was surrounded by capitalist-imperialist nations that threatened its existence. Now their leaders openly boast that they have surrounded us and that they will bury us.

So remember Kipling's warning that the time of peril is "the time of the truce of the Bear."

Members of the American Ordnance Association will not be deceived. Plans already under way for 1960 call for a greatly accelerated program, in cooperation with the three services, designed to make our country even stronger in defense armament, so that there will be no doubt that in negotiations the United States speaks from strength.

In the face of what we know about Communists and their plans for world conquest, we as a nation can survive only if we build the strongest possible front—spiritual, moral, economic, military—steadfastly and courageously to combat these sinister men.

• **The Space Race.**—The Russian success in launching a space vehicle to encircle the moon further confirmed strong statements by Maj. Gen. J. B. Medaris and Dr. Wernher von Braun, commander and chief scientist, respectively, of the Army Ordnance Missile Command. Both warned earlier of the United States lag in space exploration when a Russian rocket hit the moon; both stated that the United States could spend effectively fifty per cent more in our space effort.

Said General Medaris, "You always reach a point of optimum funding where extra money is nothing but waste—but we're only about fifty per cent of the way to optimum funding."

Dr. von Braun claimed, "We have the brains, the resources, the capability, but we are hampered by continuous evaluations, justifications, and rejustifications instead of progressing in our development of space projects."

In military missiles, the two men expressed belief that we are on a par with the Soviets, a view also stated by Dr. H. F. York. Dr. T. Keith Glennan, head of the National Aeronautics and Space Administration, reiterated the warning he has long been issuing; namely that the United States is at least a year behind in launching rockets of great thrust.

• **Nuclear Ban Problems.**—As international discussion on testing of nuclear weapons drags along, warnings have been issued by two Americans close to the problem. Thomas E. Murray, former Atomic Energy Commissioner and now consultant to the Joint Congressional Committee on Atomic Energy, points out that there is not a sound scientific basis for detecting underground tests. He is perturbed that any permanent agreement on a test ban be limited to a set number of inspections, as this would require acting in good faith by all parties, yet "historical evidence is that the term 'good faith' has no meaning in the Soviet vocabulary."

From the military point of view, Rear. Adm. E. N. Parker, Chief, Defense Atomic Support Agency, indicated that even the present ban was retarding development work. He noted that "if we are going to advance the art and maintain strength (in nuclear weapons) we must have the ability to test weapons."

An example of the setback under the nuclear ban is project Orion—a nuclear-propelled rocket program that almost has reached that stage of development when the scientists need tests to evaluate their progress.

The Defense Atomic Support Agency, formerly the Armed Forces Special Weapons Command, is directly under the Joint Chiefs of Staff. The Agency coordinates with the Atomic Energy Commission in production and stockpiling of atomic weapons and is responsible for storage, maintenance, and repair of the nuclear parts of all atomic weapons. It also helps to plan tests of nuclear weapons and analyzes test results for military applications. All training of military personnel in atomic weapons is conducted by the DASA Field Command, Sandia Base, N. Mex.

• **New Space Probe.**—The drawing on the front cover of this issue depicts a 5-stage vehicle that will be used to probe the ionosphere this November. Comprised of an Honest John, two Nike-Ajax boosters, a slow-burning Recruit (Thiokol) and Scale Sergeant (JPL) propulsion units, two of these vehicles are being assembled by the University of Michigan for the Army Ordnance Ballistic Research Laboratories and will be launched at the Wallops Island facility under the auspices of the Pilotless Aircraft Research Division of NASA.

Design of the nose-cone instrumentation and the complex ground instrumentation required for recovery of the data is a joint effort of the Ballistic Research Laboratories and the University of Michigan. The entire weight of the nose cone plus internal instrumentation is 15 pounds, and it is expected that the peak altitude of the final stage will exceed 1,000 miles.

• **Command Changes.**—The Chief of Army Ordnance has received his third star, and congratulations have been pouring in from many A.O.A. members to Lieut. Gen. John H. Hinrichs. At the same time, Brig. Gen. Joseph M. Colby,

Deputy at the Army Ordnance Missile Command, retires with the good wishes of his many friends in the A.O.A.

The Marine Corps will welcome a new Commandant when Maj. Gen. David M. Shoup takes command of the Corps on January 1, 1960, with 4-star rank upon the retirement of Gen. R. McC. Pate, the present Commandant.

• **Defense Spending.**—Wilfred J. McNeil, who resigned recently as Comptroller of the Department of Defense, served in that capacity since the position was established in 1949, having retired as a rear admiral in the Navy Supply Corps in 1947. From his years of experience, Mr. McNeil predicted that defense spending would continue at the same rate but with some changes of emphasis.

He estimated that maintenance and operating costs will decrease as missiles become predominant over aircraft and that there would be further personnel cuts—the equivalent funds going into more sophisticated weapons. He stated that the Government should support a strong military posture even though cold-war tensions may ease and noted that, although military personnel cuts will probably be small, a reduction of 100,000 men would make half a billion dollars available for weapons.

• **Military Space Projects.**—Military space projects that reach advanced stages of development are being returned to individual service control by the Defense Department's Advanced Research Projects Agency. The agency will devote more of its efforts to long-range advanced research, such as solid fuels, new defense techniques, and special-purpose materials, and turn over engineering developments to the services in an earlier phase than heretofore.

Dr. H. F. York, Director of Defense Research and Engineering, announced the projects to be turned back to the services—projects on which they actually have been doing the immediate supervision. For the Army these are: the Notus satellite-borne communications system; for the Navy, the Transit satellite-borne communications system; and for the Air Force, the Midas ballistic missile early-warning satellite and Samos (formerly Sentry) reconnaissance satellite.

The joker in this about-face is that each service will have to justify the funds for these projects that have been supported previously by ARPA money. Thus the Air Force may have to decide, within its economy budget, whether a satellite early-warning device is more essential to the Nation's defense than some other means of detecting enemy ballistic missiles.

Also in the "turnaround" the Air Force will be made predominant in space when it takes over, as planned, responsibility for development, production, and launching of military space boosters. The plan does not include the Saturn launching rocket of 1.5 million pounds' thrust. Saturn, not now applicable to military use, will become the responsibility of the NASA if Congress approves transferring Dr. von Braun and his team to that agency.

The Navy proposes a more drastic approach to coordinating space projects than announced by Dr. York. It would establish a unified command on military space development under the Joint Chiefs of Staff encompassing all research and development centers, test launching centers, and missile ranges. Each service would make requests on the command for the equipment and other assistance required by missions assigned by the Joint Chiefs.

Thus the American space exploration pot boils while Russian efforts gather momentum: "Merge the Army and Air Force in order to unify missile programs," says a congressional committee; "Merge all three services and give it all to us," says the Air Force; "Leave us alone," says the Army; and "Give it all to the Joint Chiefs," says the Navy.

• **Rifleman's Progress.**—Although Army Ordnance disclosed nine of its new weapons at the Forty-first Annual Meeting of the Association at Aberdeen Proving Ground, it has others, more revolutionary, under study. One of these, a rifle cartridge that will fire two or three bullets from the muzzle in tandem with a slight spread, was initiated in 1952 by Melvin M. Johnson, Jr., a well-known rifle expert.

Several light rifles of caliber .22 or larger with initial velocities up to 4,500 feet a second are being tested. There is also a constant effort to utilize new lightweight alloys in all weapons.

• **Boron Fuels Canceled.**—The background of the Navy and Air Force decision to cancel the development and manufacture of boron aircraft fuels is now being revealed. The decision was affected by the fact that this high-energy fuel is highly toxic to personnel, both in manufacturing and in handling. It also was discovered that an expected reduction of the cost of the fuel in large quantities did not materialize.

It was learned that a new approach to increased fuel energy by the addition of extremely fine powdered metals, such as aluminum, promises to be more effective. These considerations, plus the added fact that boron fuels were giving only moderate improvement at subsonic and supersonic speeds, resulted in the cancellation.

The Navy also was pursuing the possibilities of boron fuels and has canceled its contract with Callery Chemical Company but put its production plant temporarily in stand-by.

Since large sums have been spent in this venture, Congress is demanding that other uses for boron fuels be developed immediately.

• **Troop Transportation.**—The Army has proposed that more troops, their dependents, and light equipment be airlifted to and from overseas assignments. It points to great savings in the pipeline in man-days and in food and accommodations while awaiting transports. This move also is favored by the Military Air Transport Service which is struggling to keep an adequate number of aircraft in operation and ready in case of another "brush-fire" war.

The Military Sea Transportation Service is concerned in that it might have to take ships off its active list. These essential logistic support forces are under continuous fire from their commercial counterparts which claim, without thought of the defense needs of the Nation, that the military transportation activities duplicate scheduled services.

No Time for Halfway Armament

An Editorial

IF you were among the nearly 5,000 members who were at Aberdeen Proving Ground on October 8, 1959, for the Association's Forty-first Annual Meeting, you will get the full import of these remarks. If you were absent, possibly you will sense, in some measure, the lessons that memorable occasion taught. This observer, who has not missed an Aberdeen Meeting since the start forty years ago, saw ample evidence to justify a deep sense of pride in the Ordnance-Industry achievement in modern weapons and weapons systems.

At the same time, there was an equally deep feeling that "there is more here than meets the eye" and that, despite the progress shown, our fighting Army is by no means as strong as it should be. The Aberdeen showcase was replete with modern applications of today's firepower. But how much of it do we have ready to meet the threats to our security and peace—notwithstanding the smiles and quips of our visitors from overseas?

FIRST, there was the program of tests and demonstrations, the like of which the great Ordnance research center at Aberdeen has not equaled in four decades. Every item on the long and impressive list reflected the competence of the researchers, the developers, the producers, and the logisticians of the Ordnance Corps of the Army, aided at every turn by their opposite numbers in industry.

The up-to-date designs of conventional weapons, vastly more powerful than their predecessors of a short three years ago, packed firepower, mobility, and dependability of such proportions as to give pause to a would-be opponent. An illustrated account of the tests and displays is presented on pages 405 to 409 of this issue.

All told, the evidence of engineering skill and novel method was proof that time and money have not been lost in the appraisals of armament ideas and in the translation of those ideas into workable instruments of defense. The Army, the Ordnance Corps, the other technical services of the Army which shared the responsibility, and American industry, all are entitled to sincere congratulation, appreciation, and thanks. The Ordnance Association here records these sentiments on behalf of its 43,000 members. This was an occasion for satisfaction that one of our Nation's greatest responsibilities is in good hands.

But at the same time there were undertones of deep concern. How much of this great array of modern weaponry do we have ready in our much-heralded "Arsenal of Democracy"? Have we sufficient of these rockets and rifles, these airborne fieldpieces, these missiles, these rolling fortresses, to replace the now-antiquated gear of World War II vintage? Or is this a showcase of samples—what we can provide if given a year to eighteen months of time? We are living in an age when instant readiness is essential for survival. How then can we, in conscience, count on arming our fighting men with weapons and weapons systems to defend them against crafty antagonists who are not losing time or wasting effort or squandering money on will-o'-the-wisps but are arming to the teeth with modern conventional as well as nuclear weapons? It is folly to reduce our Army to a third-class level while we spend our largesse on frills and foibles in other areas of our national economy.

Proof? Take just one item of Army weaponry—the new light semiautomatic rifle M14. We have perfected this rifle after years of painstaking research and engineering. It is now in limited production. *But, at the present rate of funding for the production of this rifle it is easy to estimate that our Army's own needs—Regular and Reserve components—will not be met in the next ten years or more.*

Other equally dangerous conditions could be cited to show that we are blind as bats when it comes to our ability to meet an enemy on his own terms—and those terms, since the end of World War II, have been essentially in the realm of land warfare with the other arms in strong support.

ONCE again the eyes of the American people and their hopes are turned to disarmament. The hope is not new with us, nor is it peculiar to our generation. It has marked all ages in the history of the world. It is the expression of man's insatiable desire for peace—the tranquillity of order. God grant that that millennium will one day be vouchsafed to us and to all mankind!

But, as experience has shown over and over again, armament is not a cause but a consequence. It is distrust that creates the search for protection against faithless and crafty tyrants who are smart enough to arm their own people to the teeth and, thus armed, to perpetrate one act of violence after another against unarmed, peace-loving, freedom-seeking peoples and states.

The great lesson of the Forty-first Annual Meeting of the Ordnance Association at Aberdeen is twofold: (1) pride in what the Army and industry have attained; (2) concern that our arsenal of these new wonder weapons is bare. The American people in the world atmosphere of 1959 will neglect at great peril their duty to see to their defense. We should rearm —not disarm!

When the Ordnance Association was organized after World War I, the American people were hesitant to keep our weapons ready—in quantity and quality—to meet a possible enemy. Despite A.O.A. insistence, the arsenal was allowed to become depleted and out of date, and our people paid the price in blood and in substance. Now is not the time to shortchange the citizens of the United States or the Army with halfway armament.

ASSOCIATION AFFAIRS

Vice Adm. John T. Hayward Addresses Florida Post Meeting At Eglin AFB

Vice Adm. John T. Hayward, Vice Chief of Naval Operations for Development, was the guest speaker at a meeting of the Florida Post on July 6th. A sizable crowd was on hand at the Eglin Air Force Base Officers' Club for the reception and dinner. Col. Harold J. Crumly as presiding officer dispensed quickly with business matters and welcomed Maj. Gen. Joe W. Kelly, commander, Air Proving Ground Center and national A.O.A. Council representative of the Post. He then introduced Admiral Hayward.

Maj. Gen. J. W. Kelly, commander, Air Proving Ground Center, left, and Col. Harold J. Crumly, Post president, right, confer with Vice Adm. John T. Hayward, Vice Chief of Naval Operations for Development, guest speaker at Post meeting.

In his talk the admiral stressed the planning and management of research and development for the Navy. He outlined briefly the relationships among the Chief of Naval Operations, the material Bureaus with their own laboratories, and the Office of Naval Research.

Admiral Hayward stressed the widespread support the Navy receives in research through the many commercial and industrial laboratories and those of other Government services and praised industry for the great interest and devotion displayed in the development of armament for the ships and aircraft of the Navy.

A.O.A. Officials Meet in Washington To Organize New Logistics Division

Government consultants and officials of the American Ordnance Association met at the Army-Navy Club, Washington, D. C., on July 14th to make preliminary plans for the organization of the new Logistics Division.

Representing the Department of Defense were: Maj. Gen. C. J. Bondley, Jr., Director, Supply and Services, Office, Deputy Chief of Staff, Matériel, Department of the Air Force; Maj. Gen. F. A. Hansen, Office, Deputy Chief of Staff (Logistics), Department of the Army; Rear Adm. R. L. Swart, Vice Chief of Naval Material, Department of the Navy; Brig. Gen. R. G. Ruegg, Joint Chiefs of Staff; Capt. B. S. Beasley, Head, Supply Branch, Material Division, Navy Bureau of Ordnance; Capt. John V. Koch, Director, Supply Division, Navy Bureau of Aeronautics; Col. J. M. Heiser, Field Service Division, Department of the Army.

Other consultants were: Maj. Gen. Nelson M. Lynde, Jr., Chief, Field Service Division, Office, Chief of Army Ordnance; Capt. H. N. Larson, Assistant Chief for Material, Navy Bureau of Ordnance; Col. William Gurnee, Jr., Office, Assistant Secretary of the Army (Logistics); Col. Lloyd E. Johnson, Deputy Director, Logistics Plans, Office, Deputy Chief of Staff, Matériel, Department of the Air Force; Glen V. Gibson, Director for Planning and Requirements Policy, Office, Assistant Secretary of Defense (Supply and Logistics).

Representatives of A.O.A. included: Col. Leo A. Codd, executive vice-president; Col. Henry N. Marsh, vice-president, Technical Divisions; Everett L. Baugh, general chairman, Technical Divisions; Maj. Gen. Edward P. Mechling, U. S. Air Force (Ret.), staff director for technical operations; Capt. J. M. P. Wright, U. S. Navy (Ret.), staff director for Post operations; Col. Henry C. Thayer, U. S. Army (Ret.), deputy director for technical operations.

After a brief orientation on the purposes of the Association's Technical Divisions, the concept for the Logistics Division was presented. The Division will be initially composed of four Sections. The proposed Sections are: (1) Logistics Plans and Requirements, (2) Distribution and Control, (3) Transportation, and (4) Maintenance.

Basic purposes of this Division are to support Defense agencies by: (1) obtaining information on successful industry experiences in logistics operations; (2) informing industry on current and future military logistics problems; (3) considering the application of certain industrial practices and techniques to military logistics; (4) promoting increased understanding on industry's part of the need for efficient relationships between Defense agencies and industry in the field of logistics; and (5) securing industry's recommendations for action on current and continuing problems in military logistics.

The above purposes form the basis for the scope of the Division during its initial operations.

Service representatives commented favorably on the potential usefulness of this Division. To permit essential operations to proceed without duplicating the functions of other Divisions, it was generally agreed that problems in development, en-

gineering, and production of weapons and related equipment would be excluded from consideration by this Division.

Under logistics plans and requirements, techniques and preparing time-phase requirements for production items will be considered. Techniques for preparing complete logistics plans in support of national strategy also will be considered with a view to adapting successful industrial techniques as feasible.

Under distribution and control it was decided that there is a great deal to learn from industrial practices in depot and terminal design and operation. Control of inventory and material in transit throughout the entire logistics chain is an important common problem as well as the application of latest techniques in business machines and in communications.

Selecting the proper means of transportation and exercising control of the flow of material throughout the logistics chain are important problems for the Transportation Section. Consideration of techniques to improve turn-around time and make the most efficient use of all forms of transportation are of continuing importance.

There was general agreement that the demands of national strategy are creating requirements for substantial changes in maintenance operations. The problems of instant readiness of widely dispersed units make many traditional approaches to maintenance obsolete. The best talent in industry and Government working together should be able to indicate efficient approaches that will meet the requirements of national strategy.

The proper role of contractor-maintenance support in the field is a problem for current consideration. In addition to considering maintenance of equipment in the hands of troop units, there is the problem of maintenance of equipment in depot storage.

The marked degree of interrelationship among the four Sections demands frequent meetings of the entire Division. The greatest contribution this new Division can make is to provide Government agencies with adequate information on current successful industrial practices and techniques.

The American Ordnance Association will proceed to organize the industrial nucleus of this Division by selecting qualified people from companies with the most successful experience in this field. It is anticipated that a meeting of these industrial members and the Government consultants will be held in Washington in early fall.

Powder Metallurgy Section Arranges Plant Visits By Ordnance Engineers

Ordnance engineers from arsenals all over the country visited three powder metallurgy manufacturing facilities on August 26th and 27th to see the actual commercial production of powder-metallurgy parts.

As arranged by the Powder Metallurgy Section, A.O.A. Materials Division, in cooperation with the Metal Powder Industries Federation, the groups first visited the plant of the Lionel Corporation, Irvington, N. J., on August 26th.

On tour of the Dixon Sintaloy plant were, left to right: Henry Handler, Office, Chief of Army Ordnance; E. R. Atchison, New York Ordnance District; Col. Henry N. Marsh, A.O.A. vice-president; and K. M. Gleszer, president of Dixon Sintaloy, Inc.

This was followed by a 3-hour design clinic session with a panel of experienced powder-metallurgy parts producers answering questions posed by the ordnance engineers.

A tour of the powder-metallurgy facilities of Dixon Sintaloy, Inc., and Pitney-Bowes, Inc., on August 27th, afforded the engineers a chance to see the production of a broader range of powder-metallurgy parts in addition to the practical application of tooling know-how in minimizing machining operations and the generation of scrap.

As a result of the meeting, the arsenal representatives will continue to study powder metallurgy and will bring their questions and problems to the next full Section meeting. This meeting will be held at the Picatinny Arsenal, Dover, N. J., on Thursday, December 3, 1959.

Syracuse Chapter Has Season Of Renewed Activity After Its Reorganization

The Syracuse Chapter of the Empire Post enjoyed a summer of great activity, and a nucleus of Chapter members met on July 17th to map reorganization plans for the coming season and to make arrangements for their annual outdoor affair on August 21st.

Arthur D. Stone as acting chairman of the meeting pointed out the advantages of bringing industry and military personnel together on common ground to exchange information on technical and other aspects of ordnance matters. Members felt that local Chapter meetings should be limited to three a year—one in the fall, another in the spring, and a summer outing. However, special meetings will be held when required for purposes such as encouraging small business firms to seek Government contracts.

Chairman Stone appointed John H. Walsh, Fred Gangberg, and C. H. M. Roberts to the nominating committee to select a new slate of officers and directors.

Aiding in the Chapter's reorganization were John J. O'Neil, president of Empire Post, and Maj. Charles L. Harrison, newly appointed commanding officer of New York Ordnance District's Rochester Regional Office, and Secretary of the Post.

As planned, the annual outing was held at the Lake Shore Yacht and Country Club in Syracuse where light refreshments were available during an afternoon of golf and other sports. In the evening, golf prizes were awarded at an informal dinner. A turnout of nearly 200 members saw Empire Post President O'Neil win the golf trophy.

Judging from the spirit shown at the annual outing, Syracuse-Central New York Chapter is well on its way to a year of great activity.

The newly elected officers of the Chapter are: H. Follett Hodgkins, Sr., Lipe-Rollway Corporation, general chairman; Kenneth A. Digney, Oberdorfer Foundries, first vice-chairman; Col. C. H. M. Roberts, Pass & Seymour, Inc., second vice-chairman; and Dr. Dewey Sandell, Carrier Corporation, secretary-treasurer.

General Clark Analyzes Research Contract For A.O.A. Post At Hartford

A clinical analysis of an Army Ordnance research contract was presented in detail to the members of the Hartford-Springfield Post of the Association at their annual dinner meeting in Hartford, Conn., on September 14, 1959. The "doctor" in charge was Brig. Gen. Chester W. Clark, Assistant Chief of Army Ordnance and director of Ordnance research and development. He was assisted by Lieut. Col. R. G. Blaylock, and his points were emphasized by slides and graphs as well as moving pictures. All in all it was a novel, timely, and unique type of dinner-meeting address.

Not only the obstacles in the way of successful research in the area of weapons and weapons systems were described but the successes as well. Since it was a missile contract that was dissected, the successful performance of the new types as shown in pictures brought the research efforts as well as the administrative steps involved to a satisfactory conclusion for all those present.

Some 200 members of the Post were in attendance. The toastmaster was the Post President J. Alan MacDonnell of Gilbert & Barker Manufacturing Company, West Springfield, Mass. Following the National Anthem the invocation was given by Capt. John S. Sanders, Chaplain, 57th Air Division, Westover Air Force Base. Col. William J. Crowe, long a Regular Army Ordnance officer and now an official of Savage Arms Company, Chicopee Falls, presented a report as secretary-treasurer of the Post, revealing its strong position both as to members and finances. A résumé of the activities and plans of the national Association was given by Col. Leo A. Codd, A.O.A. executive vice-president from Washington, D. C.

Prominent among the guests was Col. Frederick H. Payne of Greenfield, Mass., a founder of the Ordnance Association and presently a national director. He served with distinction in the Ordnance Department of the Army in the First World War, was a member of the Cabinet of President Hoover as Assistant Secretary of War, and returned to duty during World War II on the staff of the Springfield Ordnance District.

In addition to those already mentioned, the guests at the head table included Lieut. Col. Eugene A. Smith, chief of operations, Boston Ordnance District; Col. Delwyn E. Silver, chief, supply division, Eighth Air Force Directorate of Matériel; Erle Martin, a national director of the A.O.A. and vice-president of United Aircraft Corporation, East Hartford, Conn.; Col. Oren E. Hurlbut, then commanding officer of Springfield Armory and now commanding officer of the Ordnance Weapons Command, Rock Island, Ill.

A.O.A. Fire Control Section Meets With Destroyer Group At Newport, R. I.

Dr. Alton D. Anderson, Cook Research Laboratories, Morton Grove, Ill., chairman of the Fire Control Section, Underwater Ordnance Division, presided over a vigorous 2-day meeting with Destroyer Development Group Two, U. S. Atlantic Fleet, at Newport, R. I., on Wednesday and Thursday, August 12th and 13th.

T. G. Bell, U. S. Navy Underwater Sound Laboratory, New London, Conn., outlined the efforts being made to reduce the present noise level in destroyers. The fire-control program on destroyers was described by John Kelly, Naval Underwater Ordnance Station. A final technical paper was read by S. J. Campanella, Melpar, Inc., Falls Church, Va., on "A Comparison of Analog and Digital Computers."

Capt. S. B. D. Merrill, Commander, Destroyer Development Group Two, in uniform, center, is shown with members of the A.O.A. Underwater Ordnance Fire Control Section in front of Project Dash helicopter on flight deck of U.S.S. HAZELWOOD during demonstration of this antisubmarine warfare system off Newport, R. I.

Rear Adm. E. B. Taylor, Commander, Destroyer Force, U. S. Atlantic Fleet, and Capt. S. B. D. Merrill, Commander, Destroyer Development Group Two, welcomed the conferees and reiterated their determination to improve the destroyers' weapons systems by way of a planned development program.

A series of technical lectures on the current status and expectations of Destroyer Development Group Two was moderated by Captain Merrill. "The Increasing Role of the Destroyer," presented by Comdr. George Ball, stressed the vital nature of the problems confronting destroyer development in antisubmarine warfare.

Guest speaker for the evening session was Rear Adm. Charles E. Weakley, commander, Destroyer Flotilla Two, who spoke on the activities of the destroyer command in protecting large tonnages of critical materials during national emergencies.

On August 13th, Section members boarded the U.S.S. HAZELWOOD for a cruise which demonstrated the latest development in destroyer antisubmarine warfare technique involved in project Dash—a new weapons delivery system using a remotely controlled helicopter.

Birmingham Post Members Hear General Callahan, See Film At Fall Meeting

The Birmingham Post held its fall luncheon meeting at the Tutwiler Hotel, Birmingham, Ala., on Thursday, September 10th, with more than 170 members and guests present. The presiding officer, Post President A. B. Schwarzkopf, called on J. Frank Curry, Post Vice-President, to open the meeting with an invocation.

The guest of honor, Maj. Gen. Dan F. Callahan, commander, Mobile Air Materiel Area, Brookley Air Force Base, was introduced by Louis F. Jeffers, president of Hayes Aircraft Corporation, Birmingham.

General Callahan spoke on "Support of the Air Force." His informative talk

Maj. Gen. Dan F. Callahan

was accompanied by a short film entitled "The Eagle's Strength." The general described the far-flung operations of the Air Materiel Command which are needed to support the units of the U.S.A.F. scattered throughout the world. His talk made it quite clear that the staying power of any fighting force is entirely dependent on the efficiency of its logistic support.

Louisiana Post Members Hold Fall Meeting At Shumaker Ammunition Depot

The Louisiana Post assembled in the northern reaches of its territory at Camden, Ark., for its fall meeting on Monday, September 21st. Large cavalcades from the Shreveport and Texarkana areas gathered with local members at the Shumaker Naval Ammunition Depot in the forenoon under the leadership of Post President J. Stewart Petersen.

At Shumaker NAD, the members were greeted by Capt. R. E. Johnson, U.S.N., commander of the depot, who led them on a tour of the rocket-loading and storage facilities. From Shumaker, the members dispersed for luncheon and later assembled at the Supervisors Country Club of the International Paper Company.

At the company's Camden plant, the most modern automatic machinery was in operation. The crowd was welcomed by A. G. Rozykie and Col. E. Y. Argo and divided into small groups led by company engineers who explained the processes of automatic paper manufacture as they were inspected in sequence.

The guest of honor and principal speaker at the dinner was Rear Adm. Charles B. Martell, Office, Chief of Naval Operations. Admiral Martell, who has been assisting in plans for consolidating the Navy Bureaus of Ordnance and Aeronautics into the Bureau of Weapons, recounted some of the problems involved. He also outlined the manner in which the new Bureau will operate utilizing the best features of the older two.

Executive Board Of Standards And Metrology Division Meets In Colorado

The executive board of the Standards and Metrology Division met at the National Bureau of Standards, Boulder, Colo., on July 23rd. Division Chairman C. Thorpe Thompson, Cleveland Instrument Corporation, Cleveland, Ohio, presided.

The general purpose of the meeting was to plan for the staffing and operations to cover the extended scope of the Division in the fields of electrical, electronic, and general physical standards. Discussion indicated that one of the main problems in the science of metrology concerns adequate appreciation and appraisal of the effects of temperature and environmental factors upon the accuracy of measurement.

Plans for the annual Division meeting on January 21, 1960, at the Army Ordnance Missile Command, Huntsville, Ala., include topics for papers covering the environmental characteristics and effects for measurements within the fields of dimensional, optical, electronic, electrical, magnetic, and general physical standards.

Government and military representatives will come from the Army, Navy, Air Force, and the Atomic Energy Commission and will participate in a panel discussion. It was decided that a theme of temperature and environment factors in accuracy of measurement should have a widespread interest because of today's precision challenges in weaponry.

A tour of the Electronic Calibration Center of the National Bureau of Standards, Boulder, Colo., concluded the meeting. It was pointed out that these calibration facilities are used extensively by all branches of the armed forces and their contractors. New developments included highly precise linear measuring systems for new microwave attenuation measuring machines and a microwave interferometer for measurement of the speed of light.

Logistics Division Executive Board Holds First Meeting In Washington

The executive board of the newly formed Logistics Division of the Association held its first meeting on September 25, 1959, at the Army-Navy Club, Washington, D. C. The meeting was opened by Col. Henry N. Marsh, A.O.A. vice-president for Technical Divisions, who welcomed the members of the executive board and the other conferees who had been invited to attend.

Col. Leo A. Codd, executive vice-president of the Association, then presented the Division chairman, Gen. Edwin W. Rawlings, U.S.A.F. (Ret.), financial vice-president of General Mills, Inc., Minneapolis, Minn., who conducted the meeting.

A.O.A. President Louis Polk, president of Sheffield Corporation, Dayton, Ohio, and vice-president of Bendix Aviation Corporation, Detroit, Mich., also greeted the conferees. Mr. Polk expressed the appreciation of the Association for the participation of those present and spoke of the policies and objectives to be attained by the new Division. He noted the voluntary nature of the Division and its membership in furnishing positive technical assistance to all elements of the Department of Defense and emphasized the importance of such contributions in a democracy.

A.O.A. Vice-President Harvey C. Knowles, senior vice-president of Procter & Gamble Company, Cincinnati, Ohio, discussed briefly the origin of the A.O.A. Technical Divisions. He was followed by Maj. Gen. Edward P. Mechling, U.S.A.F. (Ret.), A.O.A. staff director for technical operations, who outlined the organization of the Logistics Division.

After a detailed discussion of the func-

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tions and responsibilities of the Division, the following section chairmen were selected: E. L. Lape, operations director, United Motors Service Division, GMC, Detroit, Mich., to head the Distribution and Control Section; Maj. Gen. F. J. Dau, U.S.A.F. (Ret.), special consultant, operations group, Champion Paper and Fibre Company, Hamilton, Ohio, to head the Logistics Plans and Requirements Section; Stanley C. Pace, vice-president, Thompson Ramo Wooldridge Inc., of Cleveland, to lead the Maintenance Section; and John A. Schwab, vice-president, Pennsylvania Railroad, Washington, D. C., for the Transportation Section.

Throughout the discussions emphasis was placed upon avoiding duplication of work being done by other agencies and associations and the real need to derive solutions to problems from an ordnance viewpoint.

Particular problem areas of the Defense agencies which require better solutions were discussed by Captain B. S. Beasley, Material Division, Navy Bureau of Ordnance; Glen V. Gibson, Office, Assistant Secretary of Defense (Supply and Logistics); Maj. Gen. F. A. Hansen, Office, Deputy Chief of Staff (Logistics); Col. Lloyd E. Johnson, Office, Deputy Chief of Staff, Matériel, U.S.A.F.; Capt. H. N. Larson, Navy Bureau of Ordnance; and Maj. Gen. Nelson M. Lynde, Jr., Chief, Field Service Division, Office, Chief of Army Ordnance.

Other members of the executive board present were John Buffington, General Mills, Inc., Minneapolis, Minn., Division secretary; James M. Ewell, vice-president, manufacturing, Procter & Gamble Company, Cincinnati, Ohio; Rexford Hiney who is manager of market planning with the Raytheon Company, Waltham, Mass.; Brig. Gen. Kenneth Stiles, U.S.A.F. (Res.), vice-president, plans and programs and general director of military sales, Lockheed Aircraft Corporation, Burbank, Calif.; C. W. Williams, director, manufacturing operations, Advanced Products Organization, Chrysler Corporation, Detroit, Mich.; and John W. Young, corporate director, quality and logistics, North American Aviation, Inc., Los Angeles, Calif.

E. K. Foster, group executive and vice-president, Bendix Aviation Corporation, Baltimore, Md., was unable to attend.

The A.O.A. general chairman for Technical Divisions, Everett L. Baugh, chief engineer, Cadillac Motor Car Division, GMC, Cleveland Ordnance Plant, Cleveland, Ohio, also participated in the discussions as did Clifford E. Roberts, Washington representative of the Boeing Airplane Company.

Other conferees were Capt. L. D. Bellinger, Office, Vice Chief of Naval Material; Col. Robert T. Fincke, Office, Deputy Chief of Staff, Matériel, U.S.A.F.; Henry Handler, Office, Chief of Army Ordnance; Comdr. John A. Risser, Navy Bureau of Aeronautics; Brig. Gen. R. G. Ruegg, Office, Joint Chiefs of Staff; and Col. H. C. Thayer, U.S.A. (Ret.), American Ordnance Association.

The next meeting of the executive board probably will be called during February 1960.

Frontier Chapter's Fall Meeting Features Golf, Reception, And Dinner

The fall meeting of the Frontier Chapter of the Empire Post on Tuesday, September 22nd, was a memorable day. Affairs started off at noon with golf and swimming parties at the Niagara Falls Country Club, Buffalo, N. Y. The afternoon of sports was followed by a reception and buffet dinner in the club dining room.

Chapter Chairman William W. Seevers presided and introduced Col. David Hiester, director of field services, Ordnance Tank-Automotive Command, Detroit. Colonel Hiester gave a most provocative talk on the subject of "What Ordnance Expects from Industry."

A.O.A. Golf Tournament Brings Nearly 400 Players To Indian Spring Club, Md.

The Association's Annual Golf Tournament brought out almost 400 players at the Indian Spring Country Club, Md., on Monday, September 28th. The Washington Post, which directs this yearly event, made the usual excellent arrangements under the general chairmanship of A. E. Decker, Allis-Chalmers Manufacturing Company.

The tournament was followed by an informal dinner, after which golfers and latecomers gathered in the main hall of the club for the presentation of prizes. Stewart L. Magee, U. S. Steel Corporation, Post president, welcomed the crowd and presented miniature trophies to the winners of the two main prizes. Fred B. Zoll, Jr., of Libbey-Owens-Ford Glass Company and a director of the Washington Post, was awarded International Harvester's James L. McCaffery Trophy for his low net score of 70. William Brownrigg III, secretary for the minority, U. S. Senate, with a low net of 73 won U. S. Steel's Benjamin F. Fairless Cup.

The runner-up for low net, Col. R. C. Croward, U. S. Air Force, and for low gross, Tracey Foust, Navy Bureau of Aeronautics, each received a handsome

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prize. High score was accredited to J. T. Wills, Allison Division, GMC, who received a prize for his efforts to the accompaniment of appropriate noises.

After other golf prizes for various achievements were awarded by Norman Hayes, Autonetics Division, North American Aviation, Inc., and Golf Committee chairman, drawing began for the numerous door prizes. This event was directed by "Kenny" Hampton of Detroit Diesel Engine Division, GMC, and chairman of the Prizes Committee.

Thanks to the cooperation of the many industrial friends of the Washington Post a large assortment of most desirable items was carried off by the holders of the lucky numbers. Actually no one left empty-handed as all who attended were presented with a handy travel kit as a souvenir of the day.

Backing up the committee chairmen already mentioned were H. G. Goodwin, U. S. Steel Corporation, chairman for general arrangements, and W. J. Reed, Westinghouse Electric Corporation, the indefatigable Post secretary-treasurer who handed all the announcements and tickets.

Michigan Post Becomes Largest A.O.A. Group After Successful Membership Drive

The Michigan Post concluded the most successful membership drive in its history on July 31, 1959. There was fierce competition between the Post's East and West Teams led, respectively, by Richard M. Jones, Detroit Ordnance District, and Roy W. Huber, Ordnance Tank Automotive Command. General chairman was William J. Athanson, Jarecki Corporation. The three top "go-getters" were Stanley J. Rapsis, Chrysler Corporation; Henry Rourke, Ford Motor Company; and Elmer F. Gormsen, General Motors Corporation.

To celebrate the successful drive, Post President Mervyn Gaskin invited members of both teams to a cruise on his yacht and a victory dinner.

This record campaign resulted in over 40 new companies and 580 individuals flocking to the Michigan Post banner to make it the leading Post with a membership count of 5,198.

Puget Sound Post Visits Naval Air Station And Steel Plant For Meeting

The Navy and the Skagit Steel & Iron Works were hosts to the Puget Sound Post's fall meeting. Over fifty members traveled by bus and car to the Naval Air Station at Whidbey Island, Wash., the first stop of the meeting, on Friday, October 2nd.

At the station they were greeted by the commanding officer, Capt. Charles C. Gold, U.S.N., who divided the party into small groups to view operations on the ramps and at the airfield from which the Navy's patrol bombers cover the north Pacific barrier, always on the alert for trouble. In the repair and overhaul shops, it was evident that the technical crews were always busy ensuring top-flight maintenance of the patrol squadrons.

Across from the island at Sedro-Wooley, Wash., Ernest Jones, a director of the Post and executive vice-president of Skagit Steel & Iron Works, conducted the party on a tour of his plant. They visited the cartridge-case facility where production of 20-mm. shells was in progress and witnessed some of the intricate steel work, including construction of a special crane for a Polaris submarine tender.

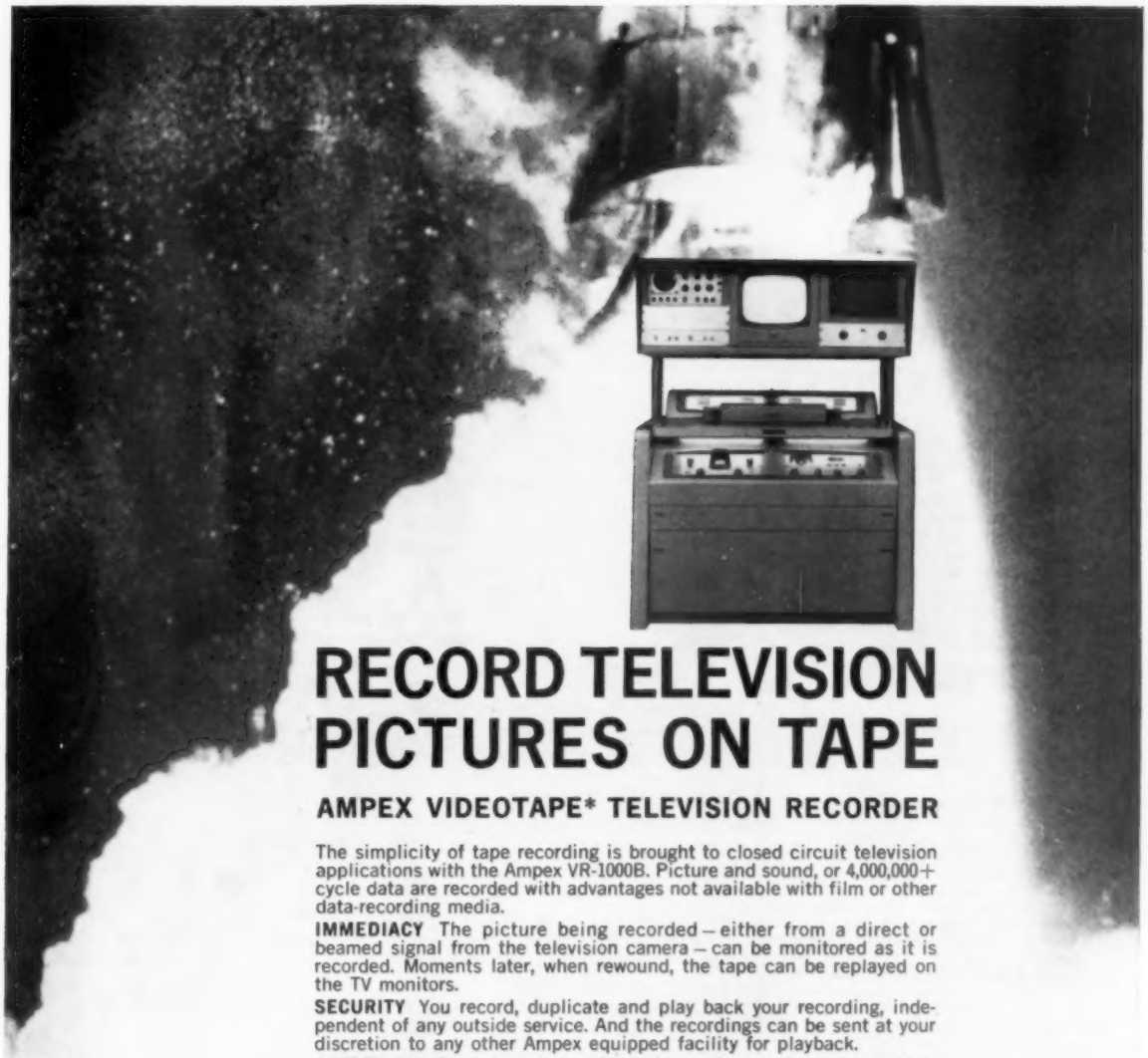
• **WALTER F. MUNFORD**, president of the United States Steel Corporation and long a member of the American Ordnance Association, died at Hyannis, Mass., September 28, 1959. For many years prior to his assuming the executive vice-presidency and later the presidency of the company at Pittsburgh, he was an active member and strong supporter of the Association's Cleveland Post.

Mr. Munford was a native of Worcester, Mass. After graduation from Worcester Polytechnic Institute he began his life-long career with the steel company, rising from helper in the open-hearth department of the wire division's south works in Worcester to the chief administrative officer of the world's greatest producer of steel.

Together with other officials and employees of his company, Mr. Munford rendered yeoman service to the national defense during the tragic days of the Second World War when increased production of quality steels was so essential to victory. During the years since, he had kept in close touch with weapons progress and gave generously of his vast experience in strengthening our industrial-preparedness potential. Not only the Ordnance fraternity but our country has lost a brilliant leader whose quiet, kindly character will be remembered with affection by those who knew him.

• **HAROLD SINES VANCE**, a life member of the Association and a recipient of its Charles L. Harrison gold medal, died at Walter Reed Army Medical Center on August 31, 1959. He had been a member of the Atomic Energy Commission since 1955 and was formerly chairman of the executive committee of the Studebaker-Packard Corporation.

As a commissioner, Mr. Vance had been especially interested in the industrial ap-



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Necrology (Contd.)

plication of atomic energy and on many occasions spoke of the need for nuclear reactors in industry.

Recently, Mr. Vance and Brig. Gen. Carlos P. Romulo, the Philippine Ambassador to the United States and the United Nations, announced the exchange of letters specifying terms of an agreement to make $500,000 available to the Philippines for a nuclear research reactor.

Mr. Vance had been associated with the Studebaker Corporation and its predecessor, the Everitt-Metzger-Flanders Company, for forty-five years before taking a Government post. He rose quickly in the industrial field because of his ability to make correct decisions in complicated situations. In 1915, he was made purchasing agent of the Studebaker Corporation.

Various sales positions followed until 1926, when he was elected vice-president in charge of manufacturing and engineering. In 1935 he was made chairman of the board of directors of Studebaker. When the company was merged with the Packard Corporation in 1954, he became chairman of the executive committee of the new corporation.

As a consultant for the Office of Defense Mobilization from 1952 to 1955, Mr. Vance was chairman of the Committee on Machine Tool Reserves.

• **BRIG. GEN. ALFRED R. GLANCY,** life member of the American Ordnance Association, industrialist, financier, and philanthropist, died at Atlanta, Ga., August 4, 1959. He served during World War II as head of the Office of the Chief of Ordnance, Detroit, and was in charge of the combat-vehicle and automotive-production programs for the entire Ordnance Department of the Army. In later years he devoted his life and his fortune to the Joan Glancy Memorial Clinic for Children at Duluth, Ga.

General Glancy was among those early engineers and industrial leaders who were associated with the General Motors Corporation during its formative years following the First World War. After his graduation from Lehigh University, he began his engineering career with Bethlehem Steel Company in Cuba.

Later he joined General Motors, becoming president of the Oakland Motor Car Division which later became the Pontiac Division. As president of the latter he directed the destinies of Pontiac and was long known in the industry for his outstanding achievements in building and marketing that automobile.

Following his retirement from General Motors, he engaged in financial operations with unusual success. Early in World War II he was called to active duty by Lieut. Gen. Levin H. Campbell, Jr., Chief of Ordnance of the Army, to head the gigantic operations of the Ordnance Department in the field of combat vehicle and automotive design procurement and production. These functions of the Department were transferred from Washington to Detroit and placed under General Glancy's management. He brought to the assignment the same executive skill and drive that had distinguished him in the automotive world. For his World War II service he was awarded the Legion of Merit.

Thereafter General Glancy's talents were turned to the Joan Glancy Memorial Clinic which he founded as a tribute to the memory of his daughter, Joan, who died in childhood. It has grown to fill a need for medical and surgical aid among children in a large area of Georgia near Duluth. He endowed it heavily and devoted most of his time to advancing its good works.

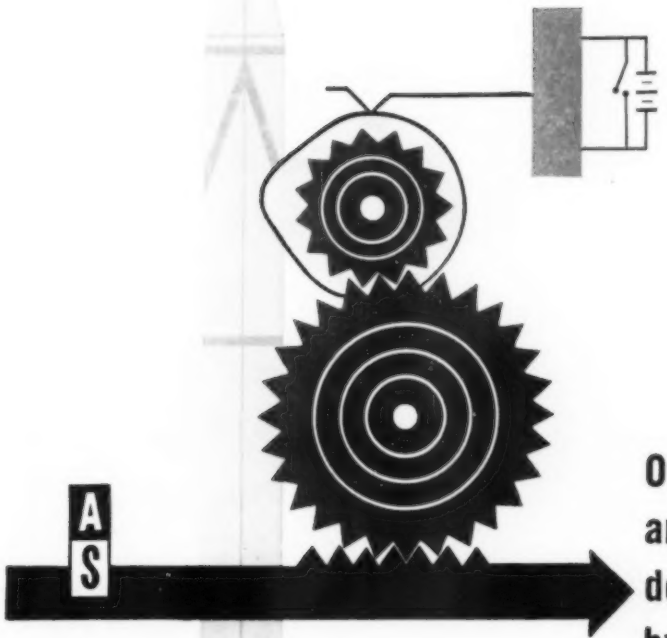
General Glancy was a loyal and firm upholder of the Ordnance cause and believed deeply in the importance of the Ordnance Association. He had a broad acquaintance with the membership, by whom he was admired, and an even larger following in the automotive industry. On his frequent visits to Washington, D. C., where he spent his boyhood, the headquarters staff of the Association had the benefit of his wise counsel and friendship. They, too, will miss him and revere his memory.

• **ERWIN LOEWY,** founder and head of Loewy-Hydropress and a vice-president of its parent company, the Baldwin-Lima-Hamilton Corporation, died on July 13, 1959, at the Beekman-Downtown Hospital, New York City. Mr. Loewy and the Baldwin company held membership in the American Ordnance Association for over fifteen years.

Prior to U. S. entry into World War II, Mr. Loewy warned the Government that this country would need special machinery for a speedy build-up of our forces and, later on, built numerous heavy extrusion press installations for the defense plants which supplied the U. S. Air Matériel Command.

After the victorious conclusion of World War II, the U.S.A.F. sent Mr. Loewy to Germany for a survey and evaluation of the German heavy-press industry. His findings led to the initiation of the Heavy Press Program of the U.S.A.F. which included the most powerful machines ever built.

Several years ago he entered the industrial field of rocket and missile handling and launching equipment and built the famous ship-motion simulator for the Polaris, launching installations for use during the International Geophysical Year, and shipboard handling and stowage systems for the U. S. Department of Defense missile program.



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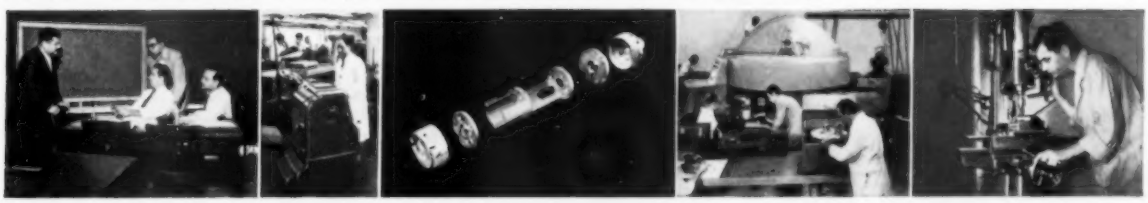

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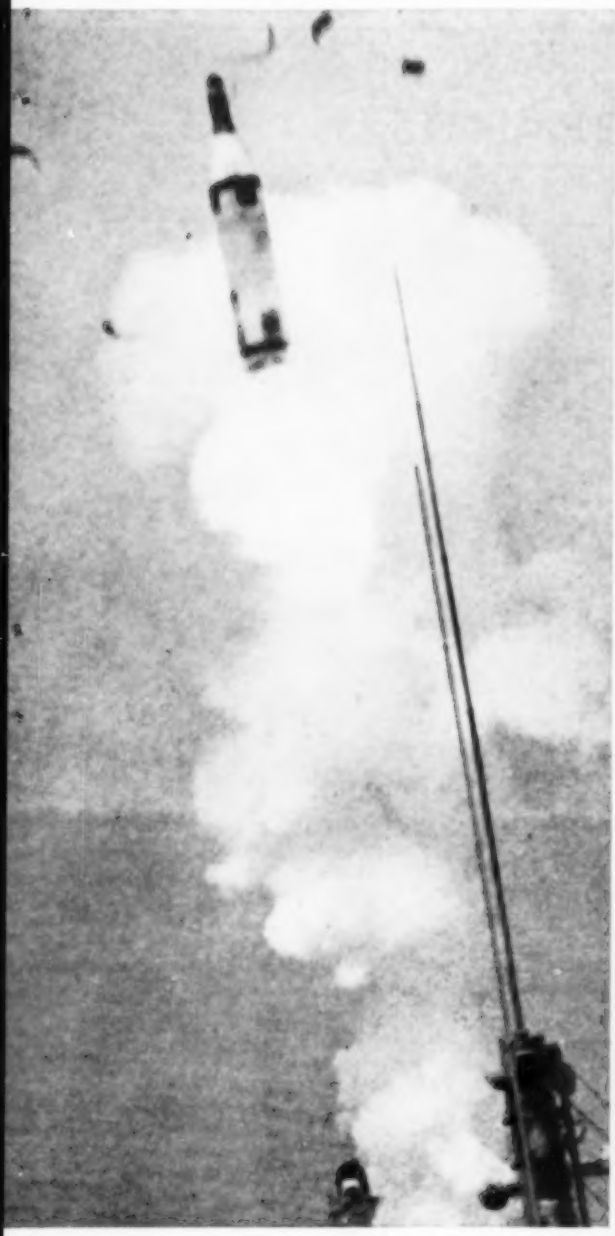
The Log of the Navy's Polaris

1958 In January, just a year after the Navy had announced its plans for a Fleet Ballistic Missile, the first Polaris test vehicle was successfully fired. Firings continued throughout 1958. By September the test vehicles were close to the final configuration of the Polaris.



1959 Operations Skycatch and Peashooter tested methods for ejecting the Polaris... Operations Pop-up and Fishhook tested a submerged launcher. In August, a Polaris test vehicle was launched from the deck of the USS Observation Island.

1960 The Polaris is scheduled for active duty in late 1960. Each of the Navy's nuclear subs will carry 16. Lockheed is prime contractor and missile system manager of a team that includes Aerojet-General, General Electric, and Westinghouse.

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NEW DEVELOPMENTS

Eagle Missile System

The Eagle missile system, aimed at achieving a new look in the Navy's long-range defense of a task force against enemy air attack, will be developed by an industry group named by the Bendix Aviation Corporation and will include Grumman Aircraft Engineering Corporation, Sanders Associates, Inc., Litton Industries, and the Air Arm Division of Westinghouse Corporation.

The Eagle is said to represent a completely new generation of air-to-air missiles. It will be fired from an aircraft at long ranges against enemy aircraft and aerodynamic guided missiles and will be designed both for maximum efficiency and lowest cost. The name "Missileer" has been given to the aircraft that will carry the Eagle.

"By emphasizing the performance of the missile," Vice Adm. J. T. Hayward, Deputy Chief of Naval Operations for Research and Development, said, "we hope to hold down costs and complexity of the airplane. With the missile-airplane combination of the Eagle and the Missileer we will be able to extend our range of air defense. We are approaching the limits in aircraft that can operate from carriers. We are contemplating a subsonic turboprop or turbofan aircraft which will have a lower performance but longer endurance."

New Radar Altimeter

A radar altimeter so sensitive a pilot can measure the height of sea waves beneath his aircraft was disclosed recently. According to the Bendix-Pacific Division of Bendix Aviation Corporation, the altimeter will be linked with a new "three-dimensional" radar system to provide automatic elevation, azimuth, and range data.

The new device enables a pilot landing his aircraft to determine within one foot his height above the runway. Flight tests have indicated that the instrument is accurate within 2 per cent at 2,000 feet. Adaptable to aircraft automatically controlled from the ground, the radar system also can be used as a manual unit or as an integral part of an automatic flight control system in a manned aircraft.

Power Supply for Subs

Development of an exceptionally small, high-density, sequenced precision power supply for use in submarines and other naval vessels where space is at a premium has been developed by the Leach Corporation, Los Angeles, Calif. The new device has a density of 2/3-watt per cubic inch, including sequence monitoring and metering circuitry.

The power supply transforms 3-phase, 400-cycle power from the ship's own generators to different D.C. supplies for devices such as digital or analog computers or automatic checkout equipment for missiles or other complex electronic instruments.

The unit measures only 9½ by 15¾ by 20 inches and includes 13 fully transistorized, high-accuracy voltage regulators supplying a total of 1,400 watts to several loads.

"Flying Duck"

The Army recently unveiled its latest concept, the "Flying Duck"—a truck that floats like a boat and "flies" above the water like an airplane. Developed by Avco Corporation's Lycoming Division under a contract with Army Ordnance, it is a multifuel gas-turbine-powered, hydrofoil version of the famed World War II DUKW amphibious landing craft.

The Duck in full flight position.

The Flying Duck uses its 860-horsepower engine in combination with aerodynamically shaped hydrofoil wings to attain water speeds up to 50 miles an hour. On water, the Flying Duck begins operation in much the same fashion as a conventional boat. However, when it reaches a speed of five miles an hour the water flowing around the hydrofoil wings which are extended below the surface acts in the same manner as does air flowing past an airplane wing. The pressure above the foil is reduced in relationship to the pressure below, giving lift.

At thirteen miles an hour this lift is sufficient to raise the vehicle well out of the water. At full flight condition the hull is more than four feet above the surface. The three hydrofoils, two forward and one at the rear, travel approximately thirty inches below the surface. With the hull completely out of the water, more than sixty per cent of the drag normally associated with boats is eliminated, thereby allowing for the tremendous increase in speed.

Navy's Tartar Missile

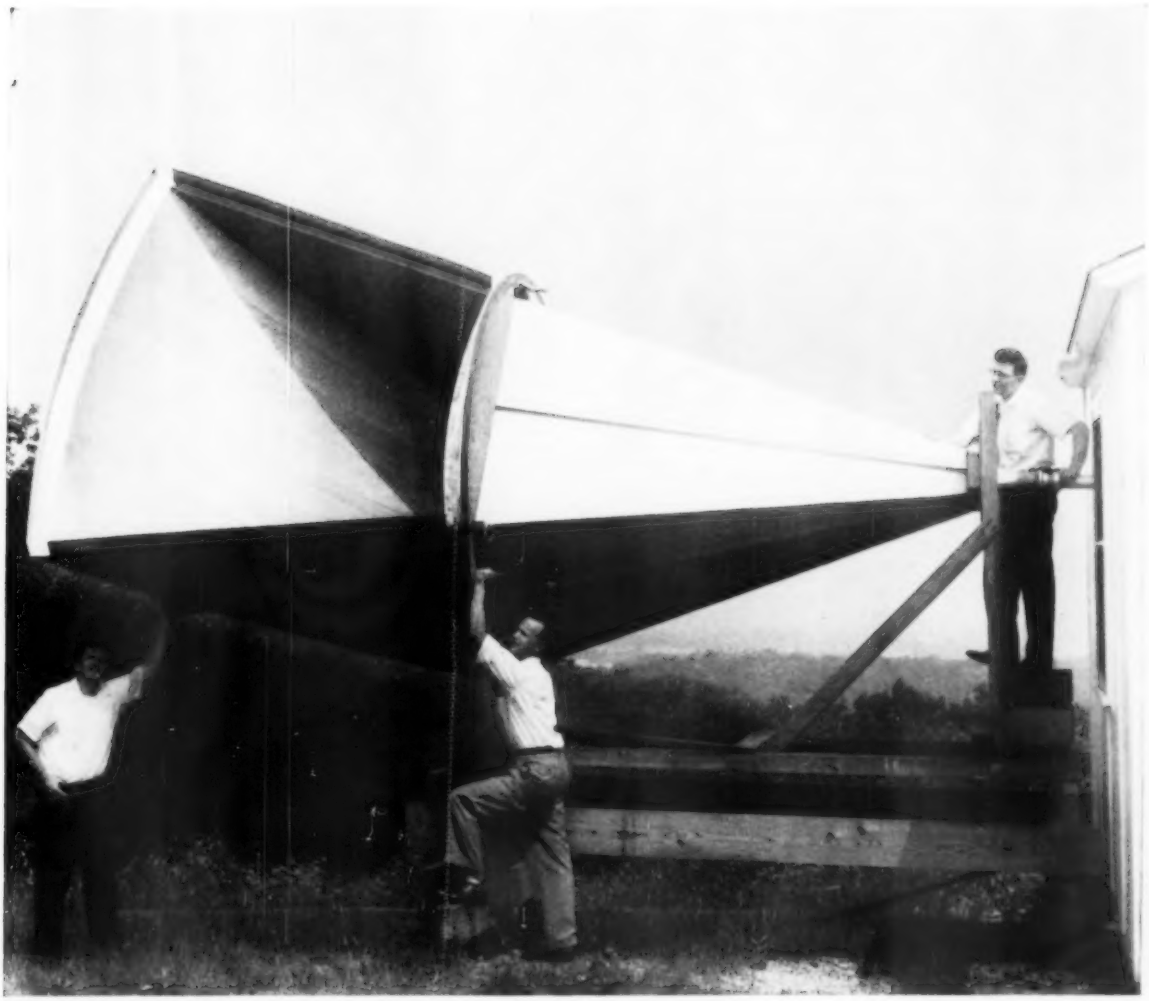
Tartar, a Navy supersonic guided missile now in production, is a surface-to-air weapon that will join the fleet next year as the primary armament of guided-missile destroyers now under construction. Tartar also will be used as the secondary armament of three guided-missile cruisers under conversion.

The Convair Division of General Dynamics Corporation is building the missile at the U. S. Naval Industrial Reserve Ordnance Plant, Pomona, Calif. Tartar was developed for the Navy Bureau of Ordnance under the technical direction of the Applied Physics Laboratory of the Johns Hopkins University, Silver Spring, Md. It is highly effective against both low- and high-altitude targets. The complete missile is about fifteen feet long and is slightly over one foot in diameter.

The single-stage, dual-thrust rocket of the Tartar launches and accelerates the missile to supersonic speed after which a lower-thrust longer-duration burning period maintains this high speed until target interception.

New Cleaning Agent

A cleaning composition that removes fuel oil from electrical equipment without harming insulation, metal, or humans and also acts as an antirust agent has been developed by the Navy. The composition, described in a recent report just released to industry through the Office of Technical Services, U. S. Department of Commerce, contains four components—hydrocarbon solvent, surfactant, penetrant, and water. In combination with a water-displacing composition developed earlier by the Navy, it quickly cleans electrical equipment fouled with oil and sea water. (*Continued on p. 436*)



At Bell Laboratories, Holmdel, N. J., a horn reflector antenna is beamed skyward by scientists Edward Ohm, David Hogg and Robert DeGrasse. The maser amplifier, which employs a ruby cooled in liquid helium, is inside building at right. Over-all "noise" temperature of antenna, amplifier and sky is only 18°K at 5600 megacycles.

ANOTHER STEP TOWARD SPACE COMMUNICATIONS

The above antenna is part of a new ultra-sensitive radio receiving system under development at Bell Telephone Laboratories. It has extraordinary directivity. Beamed skyward, it ignores radio "noise" from the earth, yet picks up extremely weak signals from outer space.

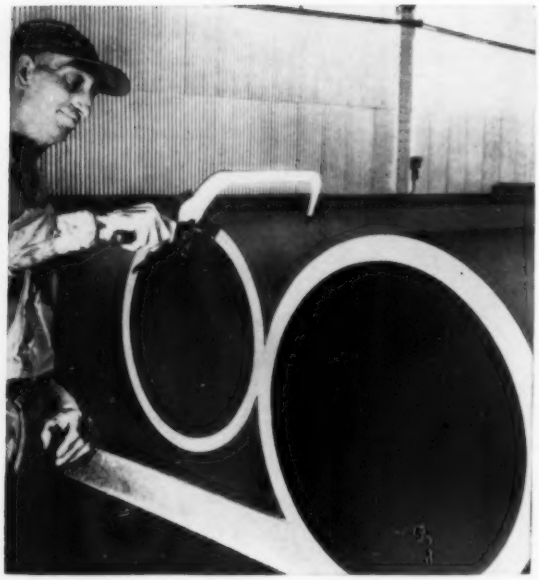
The signals are amplified by the latest Bell Laboratories "maser" amplifier. The maser principle was first demonstrated, using gas, by Prof. C. H. Townes and his collaborators at Columbia University. Bell Laboratories scientists applied it to the solid state guided by a theoretical proposal of Prof. N. Bloembergen of Harvard University. Their latest traveling wave maser amplifier employs a ruby mounted in a waveguide. The ruby is excited to store energy. As signals pass through, they absorb this energy and are thus amplified. The device uniquely combines the characteristics needed for practical space communication: extremely low inherent noise and the ability to amplify a broad frequency band.

At present the receiving system is being used to pick up and measure minute radio noise generated by the atmosphere. It also foreshadows important advances in long distance communications. For example, it could extend the range of space-probe telemetering systems, could help make possible the transatlantic transmission of telephone and TV signals by bouncing them off balloon satellites—and has numerous applications in radio astronomy and radar.

This pioneer development in radio reception is one more example of the role Bell Laboratories plays in the pursuit of better communications technology.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT



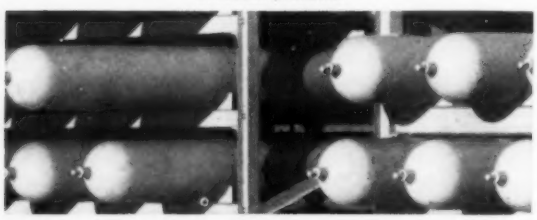
It takes inspection to maintain perfection!

This inspector is checking wall thickness on a 20-inch diameter USS National Seamless Steel Cylinder. The heavy wall thickness shown here dramatically illustrates the change from the ½-inch wall thickness so common a few years ago in the pressure cylinder field. National Tube has been a leader in the development of heavy wall cylinders, up to 3-inch thick walls, for storing gases and liquids under pressures as high as 10,000 psi.

If you have a gas or liquid storage problem, you can count on the strength and dependability of USS National Seamless Steel Cylinders. Write to National Tube Division, United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS and National are registered trademarks

The world's largest and most experienced manufacturer of tubular products.



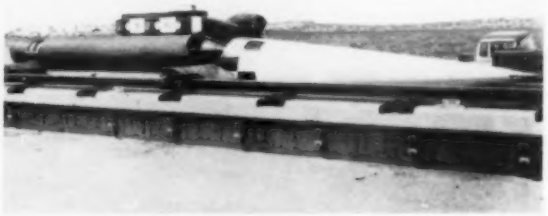
USS National Tube Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
United States Steel Export Company, New York

New Developments (Contd.)

Rocket Sled Record

A rocket-powered sled designed, built, and tested under the supervision of Picatinny Arsenal, Dover, N. J., recently set a new world speed record of 1,940 miles an hour for such test vehicles in its weight class. The record was made during a series of tests conducted on Army missile warhead sections at the Holloman Missile Development Center, Alamogordo, N. Mex.



Rocket sled is prepared for firing.

The 7,500-pound sled was carrying a warhead-section skin assembly containing a fully instrumented payload when it roared across the New Mexico desert and rammed into the face of its target, a concrete wall two feet thick. Propelled by four solid-propellant rocket motors capable of delivering 200,000 pounds of thrust, the sled was rocketed along a dual-track rail system and was in mid-air when it smashed into its target 100 feet from the end of the track.

The purpose of such a test is to simulate the changes in missile characteristics which take place at the moment of impact by the use of short-range, high-speed instrumentation.

Submarine Autonavigator

An inertial navigation system that will assist in precisely fixing the underwater launching position of the Navy's Polaris ballistic missile has successfully completed laboratory tests conducted by Autonetics, a division of North American Aviation, Inc., at Downey, Calif.

The Polaris guidance system must be given precise prelaunching position information in order for the missile to follow a ballistic trajectory to its target. This autonavigator, known as the N7A, will provide such information through the incorporation of precision gyroscopes, acceleration-sensing instruments, and a two-in-one digital computer.

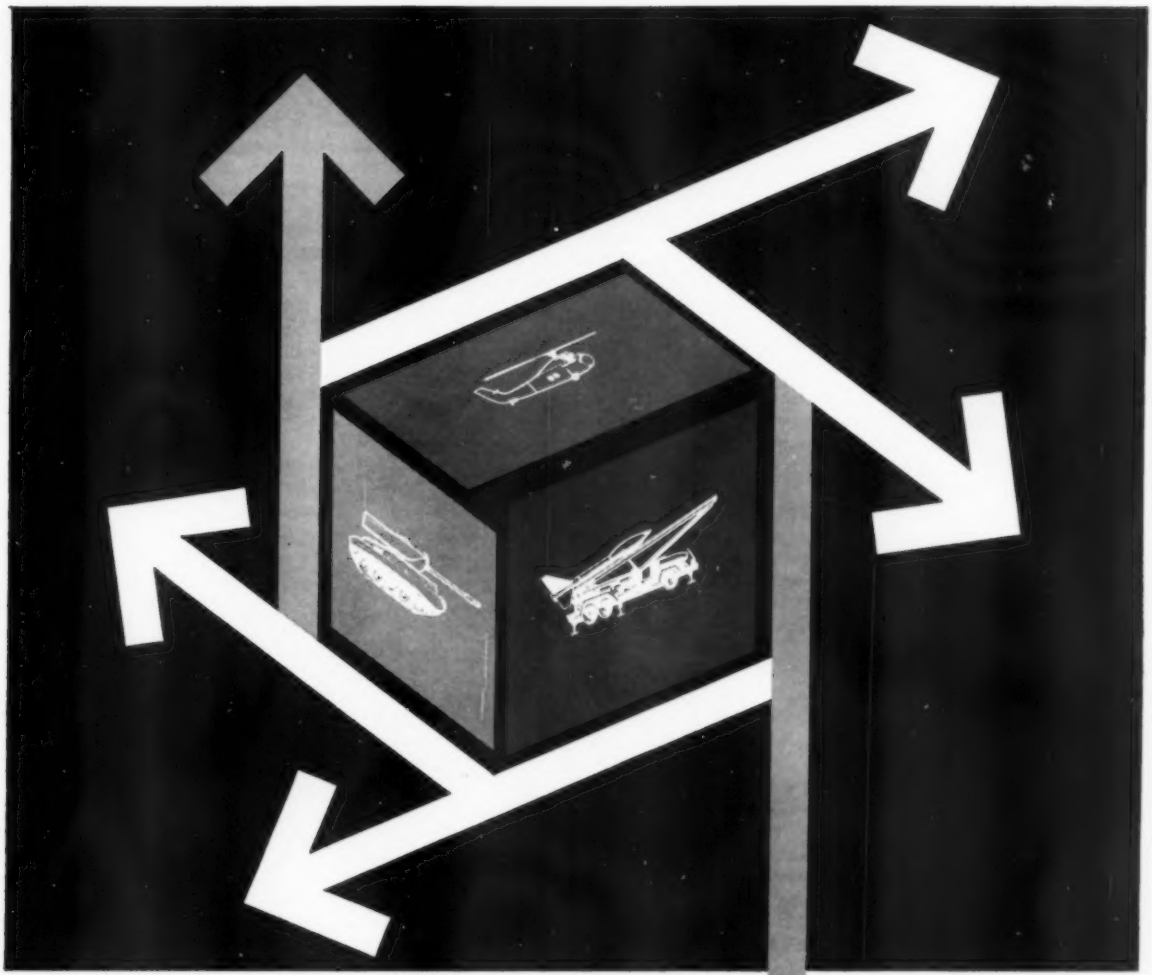
The computer, known as Verdan, is both a general-purpose computer and a digital differential analyzer. Compressed into approximately 1½ cubic feet, it can be programmed to permit accurate navigation over all regions of the earth.

Verdan is designed so that its power may be interrupted without loss of stored information. It automatically marks its place in a computation whenever a power failure is detected, and it retains the information indefinitely or until power is restored and the computation is resumed.

Except for the stable platform, all the N7A's electronic equipment is installed in a single separate navigation console. One control panel contains all the system's controls. The autonavigator is the direct outgrowth of a program initiated in 1954.

Frontline Radar

A new ultrasensitive frontline radar that can look deep into hostile territory has been developed under direction of the U. S. Army Combat Surveillance Agency. The device will detect a moving tank, truck, or jeep at ten miles or a soldier crawling on the ground two miles away. In one test a soldier walking fifteen miles away was detected. *(Continued on p. 438)*



How to put wings on a warehouse

Giving overseas air bases what amounts to local warehouse service on important parts is an Air Force objective. Its present system has slashed delivery schedules up to *20 times*...saved taxpayers several *billion* dollars over the past decade. To improve it further, Douglas has been selected to develop specifications for a comprehensive Material Handling Support System involving better communications, control, cargo handling and loading, packaging and air terminal design. Douglas is well qualified for this program by its more than 20 years in all phases of cargo transport. The company's wide experience in producing large transport systems has provided it with unmatched capabilities in this field.

Schuyler Kleinhans and Charles Glasgow, Chief Engineers of the Santa Monica and Long Beach Divisions, go over air transport needs relating to advanced cargo loading techniques with Donald W. Douglas, Jr., President of DOUGLAS

JETLINERS ■ MILITARY AIRCRAFT ■ CARGO TRANSPORTS ■ MISSILE SYSTEMS ■ SPACE SYSTEMS ■ AIRCOMB ■ GROUND-HANDLING EQUIPMENT

New Developments (Contd.)

The set scans a 30-degree sector of a battlefield. When the operator hears a suspicious sound, he can narrow the radar beam to zero in on the target. The information can be used for rapid placement of fire or various other tactical measures.

The new radar was developed jointly by the U. S. Army Signal Research and Development Laboratory, Fort Monmouth, N. J., and the Hazeltine Corporation, Little Neck, N. Y.

New Rocket Facilities

Extensive new manufacturing and testing facilities for medium and large rocket motors of the solid-propellant type were unveiled recently at the Longhorn Ordnance Works, Marshall, Tex. Included in the new facilities at the plant, which produced explosives during World War II and again during the Korean war, are a new building of over 46,000 square feet area and two new test stands capable of handling rocket motors of the largest currently planned size.

The rocket motor production facilities at Longhorn are operated by Thiokol Chemical Corporation under Army Ordnance contracts. Current production includes the motors for the Falcon (AF), Nike Hercules, Lacrosse, and Sergeant missiles. It is contemplated that the Pershing and possibly the Nike Zeus motors will be produced at the Marshall plant.

Rocket-Lift Devices

A $56,000 contract has been awarded to the Aerojet-General Corporation of Azusa, Calif., for a feasibility study of the possible use of small rocket-lift devices as a jet assist to combat troops in overcoming terrain obstacles. The concept will be explored as a means of augmenting the physical ability of the soldier by enabling him to move quickly over short distances by a series of long slides or jumps, jet-assisted, while still protected by the terrain.

The system analysis will deal with rocket thrust, weight, location, number of nozzles, flight control, human response, reaction time, and safety aspects. The present contract also will include an investigation of various propellants and logistical support.

Glass Torpedo Tubes

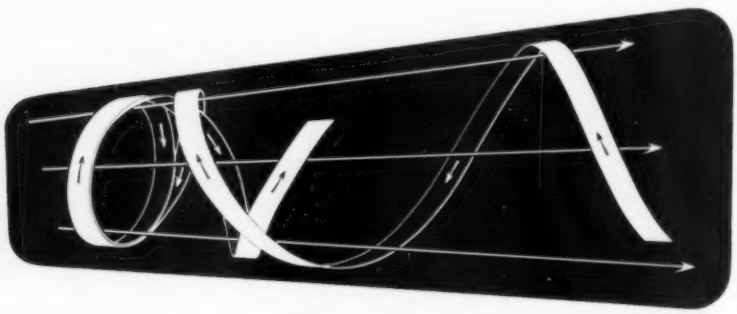
Fiber-glass torpedo launcher tubes and launcher assemblies are being manufactured for the Navy by Apex Fibre-Glass Products, a division of White Sewing Machine Corporation. About 600 tubes and 20 complete launcher assemblies will be produced. The tubes are for the Navy's new Mark 32 three-tube launchers—the first such naval armament to be made out of fiber glass—and its use enables substantially reduced "topside" weight on surface craft. In addition, the fiber-glass launcher tubes eliminate the corrosion common to steel armament and also eliminate the necessity for painting and other maintenance.

Chemical Firefighter

A new chemical compound, considered to be twice as effective as any other extinguishing agent against liquid fuel and electrical fires, has been adopted for emergency use at Army installations. Developed by the Army Engineer Research and Development Laboratories, Fort Belvoir, Va., the new agent can be used in temperatures as low as 65 degrees below zero and will be particularly helpful in the Arctic, where fire is a crucial problem. Nontoxic and noncorrosive, it also can be used safely in homes.

Sub Simulator

A new device that simulates submarines electronically is being delivered to the Navy to speed training in antisubmarine warfare. Produced by the Raytheon Company, the new sonar trainer is the first to make training possible at sea without scheduling other submarines to act as targets. Its synthetic target, indistinguishable



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Your advanced degree in physics, electronic engineering or mathematics should be backed by demonstrated technical achievement . . . a thorough understanding of the laws of cause and effect, and sound application of scientific method.

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Inquiries are invited from qualified scientists.

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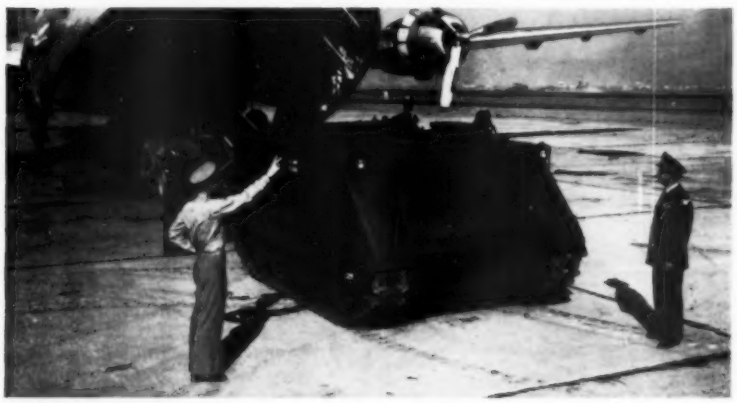
New Kaiser Aluminum Weldable Alloys

Aluminum alloys 5083 and 5086 have been developed by Kaiser Aluminum for welded structures requiring maximum joint strength and efficiency, particularly those subject to impact or dynamic loading.

Kaiser Aluminum alloys 5083 and 5086 are high strength, non-heat-treatable, weldable alloys offering seven distinct advantages:

1. **GREATER DESIGN EFFICIENCY FOR WELDED STRUCTURES.**
2. **SUPERIOR WELDING CHARACTERISTICS.**
3. **EXCELLENT FORMING PROPERTIES.**
4. **HIGH RESISTANCE TO CORROSION.**
5. **ECONOMY EQUAL TO OTHER NON-HEAT-TREATABLE ALLOYS.**
6. **IMPROVED WELD ZONE DUCTILITY.**
7. **HIGH STRENGTH IN THE AS-WELDED CONDITION.**

These weldable alloys are designed with improved properties for products subject to impact or dynamic loading. They have proved, through extended testing and on-the-job use by many industries, complete reliability under every requirement imposed upon them.



A new amphibious, air transportable and air-droppable aluminum armored personnel carrier, the M113, built by Food Machinery & Chemical Corporation's Ordnance Division, San Jose, California, is shown being loaded aboard an Air Force C-124. The M113 was engineered and developed under the direction of Ordnance Tank-Automotive Command U. S. Army to replace the steel model M59. The hull of the vehicle is primarily made of Kaiser Aluminum alloy 5083 plate, extrusions and forgings.

FASTER WELDS POSSIBLE

An outstanding characteristic of these high magnesium-aluminum alloys is their ability to take full advantage of inert-gas, shielded-arc welding methods. Fast, superior welds and pressure tight joints are thus assured. These are the strongest A.S.M.E. approved aluminum alloys available for the fabrication of unfired pressure vessels without thermo stress-relieving.

Many military products are now being made better at less cost with Kaiser Aluminum alloys 5083 and 5086. The M-113 track vehicle illustrated in Figure 1 is one example. Others include such products as missile structures and skins, missile containers, cryogenic tanks, radar antenna, destroyer gun mounts, crew boat hulls, bridges, overhead cranes, flatbed trailers and armored and amphibious vehicles.

Available in sheet, plate, forgings and extrusions in annealed and rolled tempers, alloys 5083 and 5086 make possible hundreds of new uses for aluminum in military applications. If you want further information, we'll be glad to assist you. Our staff of specialists in metallurgical research, product engineering and field engineering is at your disposal. Call or write:

Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

FREE! A Complete Portfolio On Aluminum In The Defense Industry

For your information and reference, Kaiser Aluminum offers the complete results of its comprehensive survey of the uses of aluminum in the missile industry – plus data on alloys 5083 and 5086 as used in cryogenics and other military applications. For your free portfolio, write for "Aluminum In The Defense Industry": Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

TYPICAL MECHANICAL PROPERTIES OF ALUMINUM ALLOYS 5083 AND 5086 COMPARED TO ALUMINUM ALLOY 6061 AND MILD STEEL

	5083		5086				6061				Mild Steel
	"O"	"H113"	"O"	"H32"	"H34"	"H112"	"O"	"T4"	"T6"	As Welded	ASTM A201B
Tensile Strength (psi)	42,000	46,000	38,000	42,000	47,000	39,000	18,000	35,000	45,000		60,000 Min.
Yield Strength (psi)	21,000	33,000	17,000	30,000	37,000	19,000	8,000	21,000	40,000		32,000 Min.
Elongation (% in 2")	22	16	22	12	10	14	30	25	17		25
Fatigue Strength, psi		23,000			15,000	22,000	9,000	14,000	14,000		34,000
Ultimate Shearing Strength	25,000		23,000		27,000		12,000	24,000	30,000		42,000
Mod. of Elasticity, psi	10.3×10^6		10.3×10^6				10.0×10^6				30.0×10^6
Estimated Welded Joint Efficiency		91%				91%	100%		98%	67%	100%
Typical Prop. of Sound Welds (Machined Flush)									**Reheat Treated to T6**		
Tensile Strength (psi)		43,500				39,000			43,000	29,000	66,000
Yield Strength (psi)		22,000				17,000			30,500	17,000	55,000
Elongation (% in 2")		16				21			5	5–13	25%
Filler Alloy		5183				5356			5356	5356	E6020

TYPICAL PHYSICAL PROPERTIES

	5086	5083	6061	Mild Steel
Density (lb./cu. in.)	.096	.096	.098	.284
Specific Gravity	2.66	2.66	2.70	7.88
Thermal Conductivity at 25°C (CGS units)	.30	.28	.39	.12
Average Coefficient of Thermal Expansion 68°F to 212°F (approx.)	13.2×10^{-6}	13.2×10^{-6}	13.1×10^{-6}	7.2×10^{-6}
Melting Range (approx.)	1084–1184°F	1065–1180°F	1080–1200°F	2600–2800°F

NOMINAL CHEMICAL COMPOSITION

5086:	Magnesium, 4.0%;	Manganese, 0.45%;	Chromium, 0.10%	
5083:	Magnesium, 4.45%;	Manganese, 0.75%;	Chromium, 0.10%	
6061:	Magnesium, 1.0%;	Copper, 0.25%;	Silicon, 0.60%;	Chromium, 0.25%
A201B:	Carbon, 0.20%;	Manganese, 0.60%;	Phosphorous, 0.02%;	Sulfur, 0.02%; Silicon, 0.23%

KAISER ALUMINUM

THE BRIGHT STAR OF METALS

from real "echoes," may be cleared from sonar scopes immediately should a second target appear. The device simulates all real maneuvers including dives, varying courses, speed changes, and torpedo attacks.

VTOL Craft Tested

The U. S. Air Force 16½-ton X-18, the Western world's largest vertical take-off aircraft, has completed 90 per cent of its ground test program, and has been transferred from Moffett Field, Calif., to Edwards Air Force Base, Calif., where flight testing of the tilt-wing aircraft will be conducted.

Wing of X-18 rotates 90 degrees for vertical take-off or horizontal flight.

Moffett Field tests consisted primarily of prolonged engine run-ups at speeds from idling to the maximum available (11,000 horsepower) at all wing-tilt angles from zero to 90 degrees. Functional tests included Allison vibration surveys of the two T40 turboprop engines, studies of fuselage vibration characteristics, and testing of the pitch control diverter and tail-pipe installations, with power supplied by the Westinghouse J34-WE-36 jet located in the fuselage.

Nonsparking Metals

The sparking characteristics of metals can be determined by a technique devised by the Navy for selection of materials safe for use in explosive atmospheres. A report on the method, which also identifies safe and unsafe materials, has just been released to industry through the Office of Technical Services, U. S. Department of Commerce. The technique involves a spark test using a gasoline and oxygen-enriched air mixture. A clear distinction is made between safe and unsafe metals. The Navy used the method to establish test requirements for nonsparking tools.

Among metals identified as safe to use in tools or other devices in explosive atmospheres are manganese bronze, phosphorus bronze, aluminum bronze, commercial brass, aluminum, and beryllium copper. Unsafe metals include carbon steel, carbon tool steel, high-speed tool steel, stainless steel, and monel. Metal wheel and metal rod combinations were found safe, while abrasive wheel and metal rod combinations were unsafe.

Radio Rescue Beacon

A lightweight radio rescue beacon for use in military aircraft has been developed by the Crosley Division of Avco Corporation. The beacon sends out a signal which can be picked up several thousand miles away, and rescue aircraft and ground parties can home in on its signal. It will continue sending for twenty-four hours.

An unusual feature of the device is a small, blimp-shaped balloon that is filled with helium and which carries a radio antenna wire to a height of some fifty-five feet above the ground. Miniature radio transmitters begin broadcasting rescue signals twenty seconds after the beacon is released from the aircraft.

New Landing Craft

A new amphibious full-tracked landing vehicle for the movement of personnel or cargo is being developed by Jered Industries, Inc., Hazel Park, Mich., for the Marine Corps under a contract with the Navy Bureau of Ships. It is powered by a General Electric T58 1,050-horsepower turboshaft engine.

Known as the LVTPX-10, it is 29 feet long and weighs 85,000 pounds. As a personnel carrier the vehicle can land forty-six fully equipped Marines or it can carry ten tons of payload afloat or ashore.

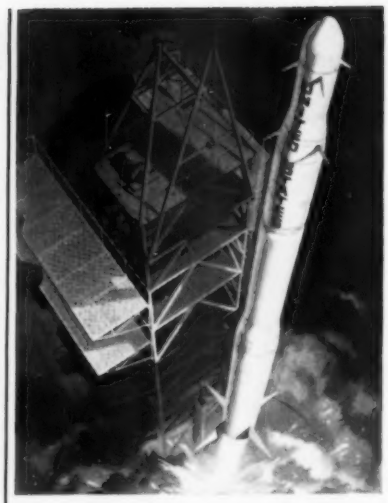
Lightweight Search Radar

A production contract of approximately $11,226,174 for a new and advanced transportable search radar has been awarded to the Radio Corporation of America by the U. S. Navy Bureau of Ships. The new lightweight equipment will be for use by the Marine Corps in amphibious assault operations. Its purpose is to provide a quick means of searching the skies for aircraft or other objects. Weighing approximately half as much as previous radars of this type, the new UPS-1 equipment has twice the detection range. It is also much more flexible and easily carried.

Microwave Garnet

A new material, the hybrid garnet, which offers a unique combination of characteristics heretofore unavailable in microwave materials, has been developed in the Motorola solid state materials laboratory, Phoenix, Ariz.

The new material exhibits an extremely narrow line width of 30 oersteds at X-band, a low saturation moment of 670 gausses, substantially improved temperature characteristics with a Curie tempera-



VOUGHT BROADENS SPACE STUDIES

The *Scout*-type research rocket is a primary interest at Chance Vought, where this company's Astronautics Division is investigating the space-science as well as the military potential of such a vehicle.

Potential missions include boosting weather, commercial or military communications stations into space.

Astronautics Division concept studies of a passive electronics satellite and a reconnaissance satellite are producing additional valuable data in new and challenging areas.

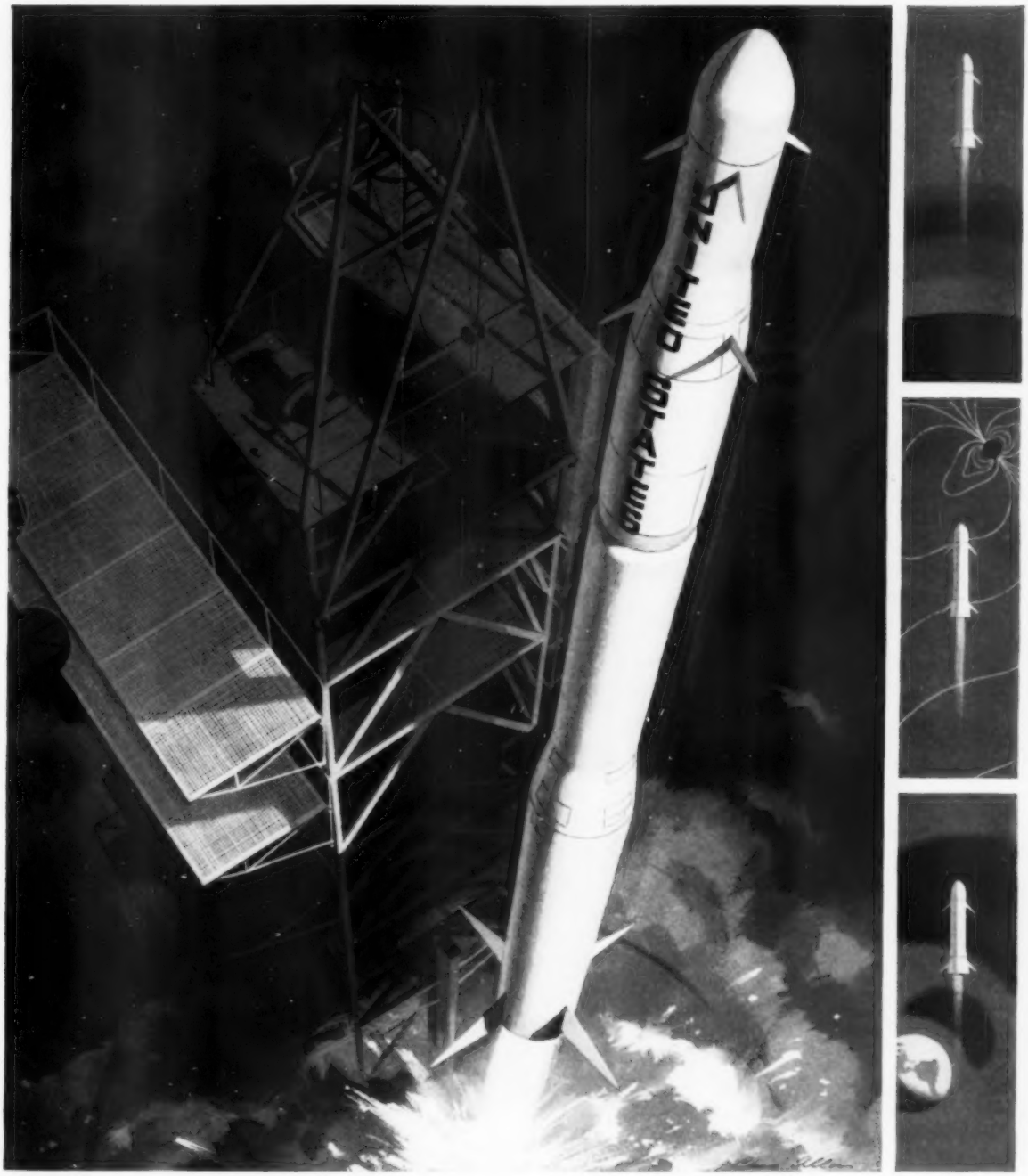
Manned payloads for space are another major objective. Vought's work includes the man-carrying portion of the vehicle, and long-range studies aimed at training for space flight.

In specializing on crew quarters for space, this company draws on unequaled experience in human factors design for high-performance aircraft. As a member of the Boeing *Dyna-Soar* development team, Vought already has found this experience applicable to space.

Toward training for space flight, Vought has designed an orbital flight simulator. In a realistically furnished cockpit, using a new family of controls and instruments, the space trainee can "maneuver" into orbit and back to earth. More than 200 such "flights" have been made to date.

Space is the specialty of Chance Vought's Astronautics Division. Other major interests are being aggressively advanced in the Aeronautics Division – where attention is on atmospheric missiles, antisubmarine apparatus and piloted aircraft – and in the company's Electronics, Range Systems and Research Divisions.

CHANCE VOUGHT
DALLAS, TEXAS



NASA'S SCOUT WILL MARK A TRAIL FOR MAN TO FOLLOW

Scout is designed to explore paths into space . . . at low cost. The inexpensive, 70-foot research rocket will go after vital space measurements that require sounding after sounding. National Aeronautics and Space Administration scientists will use the vehicle to launch the satellites and probes that measure the ionosphere, map magnetic fields and gauge radiation. Chance Vought's job is to assemble *Scout's* four stages, build its airframe and launching tower – holding to low cost and high reliability standards. *Scout* will make many of the hundreds of space soundings NASA already has scheduled. From this rocket's well-blazed trail, scientists may unlock secrets that will pave the way for extended manned space flights.

CHANCE VOUGHT
DALLAS, TEXAS

ture of 180 degrees centigrade, and the usual low loss factor required of microwave ferrites. The unique combination of characteristics is expected to make possible a wide range of microwave applications over a frequency spectrum of 4,000 megacycles down to several hundred megacycles.

Dual Ejection Seats

A new rocket-propelled aircraft escape system, made by the Columbus Division of North American Aviation, Inc., is now operational on all the Navy's T2J jet trainer aircraft.

With the system, ejection from the T2J is automatic, with the instructor using a command selector device to eject the rear pilot. The front pilot is ejected four tenths of a second later. If the instructor is disabled, the student pilot can control the system.

New Radar Antenna

A rotating 50-ton "boxcar-shaped" radar antenna, 104 feet long to warn against enemy air attack is being tested for use with the Nation's Sage defense network. The new system, called AN/FPS-28, is one of the Air Force's most modern "heavyweight" radars designed to feed advanced warning data into a central combat center. Final system tests are expected to be held at Houma Air Force station, sixty miles southwest of New Orleans.

Developed for the U. S. Air Force by Raytheon Company under a $20 million engineering program, the new-generation "supersentry" will detect invaders hundreds of miles away to give early warning.

The unique antenna array represents a considerable advance in the state of radar antenna art. Its immense size is required to perform its distant warning task. The antenna will be tower-mounted on a 3-story transmitter-receiver structure housing the 262 separate units making up the system. Over-all system weight is 800 tons.

The Sage defense system gathers and computes early-warning data and decides the best retaliatory tactics against targets. Sage results are fed into NORAD (the North American Air Defense Command) at Colorado Springs, Colo.

Nike Zeus Research

A contract totaling $188,402,905 has been awarded to the Western Electric Company, New York, N. Y., for research and development work on the Nike Zeus antimissile system.

Work on the contract will be performed at the Bell Telephone Laboratories, Whippany, N. J.; Western Electric Company, Burlington, N. C.; Douglas Aircraft Company, Santa Monica, Calif.; Goodyear Aircraft Company, Akron, Ohio; Lear, Inc., Grand Rapids, Mich.; Sperry Gyroscope, Great Neck, N. Y.; Burns and Roe Company, New York, N. Y.; Remington Rand Univac, St. Paul, Minn.; and Continental Can Company, Coffeyville, Kans.

Drying Gunstock Blanks

Army Ordnance has experimented with the new electrokiln method of drying lumber with good results on black-walnut gunstock blanks. Blanks were dried from a moisture range of 10 to 14 per cent to a range of 4 to 6 per cent in only a few hours, compared with 14 days by conventional methods.

In this method of kiln drying, which is a new application of dielectric heating, power is supplied by a radio-frequency generator, and the heat radiates outward from the core of the wood, driving the internal moisture before it to the surface. The temperature of the wood and the kiln can be rapidly established and maintained or controlled to suit the requirements of the wood in process.

Distant Target Detection

A method of detecting targets consisting of large volumes of ionized gas, at considerable ranges, has resulted from a combination of scientific discoveries by the Office of Naval Research under the name Project Tepee. Such targets may well result from the detonation of a nuclear weapon or the launching of a ballistic missile.

The detection method (discussed briefly in the September 1959 issue of ORDNANCE) is based on a new kind of radar—high-frequency ionospheric back scatter radar. Conventional radar is limited in range in the same way and for the same reason that television is—the waves travel in a straight line and can't look beyond the horizon.

Ionospheric back scatter radar resembles radio. The waves sent out by the transmitter are reflected by the ionosphere—a thick layer of charged particles above the surface of the earth. When a large rocket is fired, the hot gases coming from the exhaust also are ionized. They, too, reflect radar waves. Putting these facts together led Dr. William J. Thaler of the Office of Naval Research to conceive the possibility of warning of a missile attack by this means.

Although the feasibility of the method is a result of extensive research in ionospheric physics (significant advances in radar development have resulted from studies of ionospheric physics at the Naval

(Continued on p. 446)

For centuries angles have been read directly

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Write for Bulletin 8600-O

MOTOROLA MILITARY ELECTRONICS CAPABILITIES REPORT:

Strategic Deployment of Technical Personnel

Dr. Daniel E. Noble, Executive Vice President, Motorola, Inc.

"Dynamic organization...not static...is the key to productive use of technical talent in the field of military electronics."

The next two pages tell how Motorola has achieved "dynamic organization"...

William S. Wheeler, Vice President and General Manager
Military Electronics Division

Arthur Reese, Vice President and General Manager
Communications Division

Three field commanders direct day-to-day activities of Motorola's technical divisions. Wheeler's Military Electronics Division concentrates directly on military problems, drawing on the resources of Reese's Communications Division (world's largest producer of two-way communication systems) and Hogan's Semiconductor Division (world's largest producer of power transistors and leader in mesa transistor development and production). Behind this technical task force stands Motorola's strength in consumer electronics; in an emergency the company's total complex of 18 plants in four states can be converted to mass production of military equipment.

Dr. Lester Hogan, Manager
Semiconductor Products Division

Of Motorola's 2,000 engineers and scientists, four out of five work under the direction of Dr. Daniel E. Noble, Executive Vice President. One of the three divisions under his command is devoted exclusively to military electronics; two others provide strong support. Working together, they form a

MOBILE TECHNICAL TASK FORCE

Officials of the Air Force Flight Test Center at Edwards faced a particularly knotty problem. Specialized microwave equipment was required to relay telemetry from aircraft in remote areas.

At the request of the military, Motorola rapidly assembled the talent and equipment of its tri-divisional technical task force. Heaviest contributions to the project were made by Motorola's Military Electronics Division. But important help came from other sources: microwave equipment and vhf receivers from Motorola's Communications Division; specialized transistor circuitry from the Semiconductor Products Division.

With this swift concentration of technical talent drawn from a diversity of company sources, Motorola was able to solve a major problem for the Air Force in record time.

Few organizations serving the military today can so rapidly merge diverse technical talents and productive capacities as can Motorola. Its three "task force" divisions, under the single command of Dr. Daniel Noble, can be marshalled almost overnight for the solution of urgent military electronics problems. Cross-fertilization of ideas and techniques is the certain result.

The success of this flexible organizational structure was again demonstrated by Motorola's part in the development of the Project Mercury Space Capsule. The Capsule's command control receiver, developed by Motorola's Military Electronics Division, is the smallest all-transistorized radio receiver of its type available, thanks to mesa transistors developed by the Semiconductor Division and miniaturization techniques borrowed from packaging specialists of the Communications Division. In another instance, Motorola's Semiconductor Division developed the first samples of a new type of electronic facsimile paper with important military applications.

In an era marked by a chronic shortage of competent brain-power, Motorola's strategic deployment of its technical resources is an effective answer, both in the solution of current problems and in conducting long-range research.

Strategic deployment of manpower is only one of the reasons why Motorola is able to design, develop and produce military systems and equipment with speed, economy and reliability. Motorola's exclusive concentration in electronics, its cost-conscious approach to producibility, and its preoccupation with reliability, are evident in every Motorola military product, from the smallest solid state device to the most complex weapons systems.

For a comprehensive brochure on Motorola's Military Electronics capabilities, write: *Technical Data Service, Motorola, Inc., Military Electronics Division, 8201 East McDowell Road, Scottsdale, Arizona.*

MOTOROLA

Military Electronics Division / CHICAGO • PHOENIX • RIVERSIDE

Engineers and Physicists interested in career opportunities are invited to write: Motorola, Inc., Military Electronics Division

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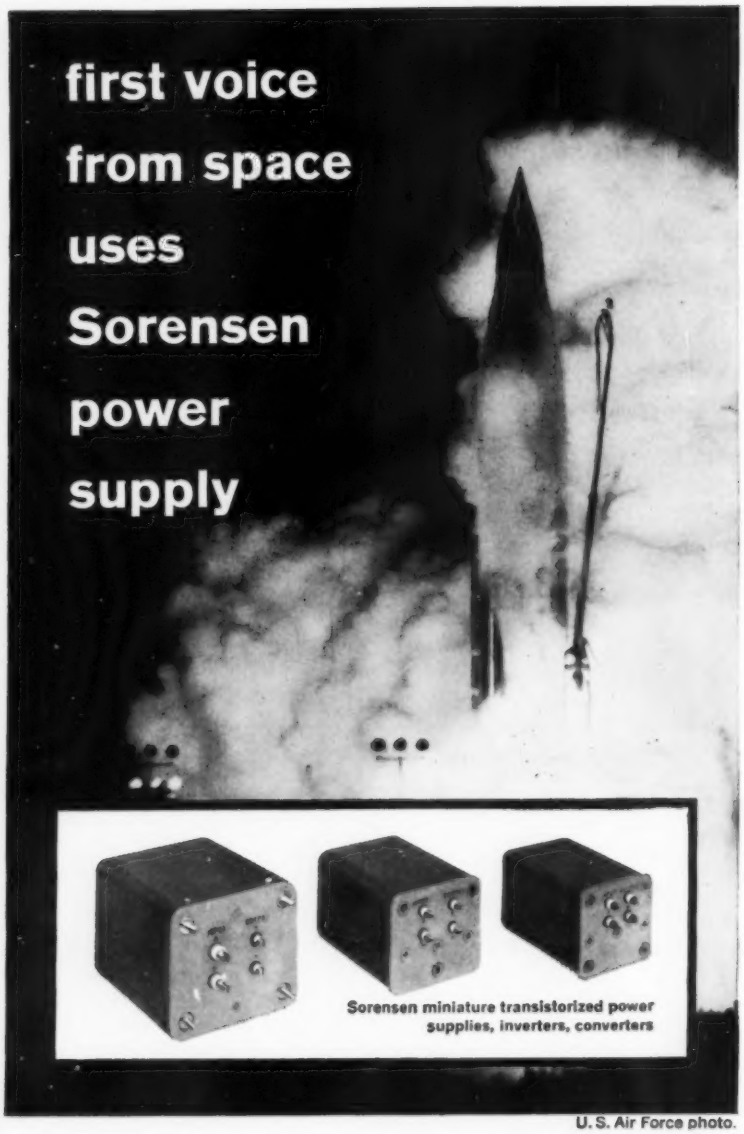

U. S. Air Force photo.

Last December, a Christmas message from outer space heralded a new era in radio communications.

Coming from an orbiting, 80-foot-long U. S. Air Force **Atlas** missile, the voice was broadcast over U. S. Army Signal Corps designed communications equipment. We at Sorensen, are proud indeed that a miniature Sorensen transistorized power supply was selected as part of this communications equipment.

Transistorized supplies for every purpose. Sorensen manufactures a complete line of miniature transistorized power equipment including: highly regulated a-c powered d-c supplies, dc-to-dc converters and dc-to-ac inverters. They are rugged, compact and as simple to incorporate into your equipment as an ordinary transformer or other "potted" component. They are available in an extremely wide variety of input-output voltage combinations and current capacities. Write for complete data.

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NEREM '59 Commonwealth Armory, Boston, Nov. 17, 18 & 19

Research Laboratory) and plasma physics (the study of the behavior of gases at temperatures of thousands or millions of degrees), the equipment required is relatively simple and inexpensive.

The same basic techniques also have demonstrated a capability of detecting a nuclear explosion from thousands of miles away. Thus it could be employed as one means of discovering violations of a nuclear test ban.

Wire-Guided Torpedo

The Navy's Mark 39 wire-guided torpedo, developed by Vitro Laboratories, resembles conventional torpedoes but is actually an underwater guided missile capable of tracking and destroying its target despite countermeasures and counteractions.

The weapon is connected to its launching vessel by a wire that is paid out, spiderlike, from the torpedo as it drives through the water. Operators aboard the launching vessel send electrical signals over the wire to guide the torpedo.

Conventional torpedoes, always have been limited because they must be fired at the predicted future position of a target, which may change through enemy evasive action. With the wire-guided torpedo the Navy took a step in underwater ordnance that is analogous to the progress from the projection-fired antiaircraft shell to the guided missile.

New Army Transport

The YAC-1 Caribou, a transport aircraft capable of carrying a platoon of infantry from rear areas to improvised air strips in forward battle zones recently was accepted for the Army by Lieut. Gen. Arthur G. Trudeau, Army Chief of Research and Development, from De Havilland Aircraft of Canada, Ltd., at Downsview, Ontario, Canada. The Caribou, a 32-passenger transport airplane with a cargo capacity of three tons, will fill a vital need of the Army for an air vehicle capable of rapid movement of small but effective combat units. In accepting three of the aircraft from De Havilland, General Trudeau said:

"Having operated under severe weight and other restrictions for some period of time, it is particularly gratifying to the Army in these days of rapidly changing warfare to obtain carriers such as the Caribou. . . . The ability to move above the surface of the earth with vehicles like the Caribou and other kinds of air vehicles necessary to move our combat forces rapidly in the combat area could have the most profound effect on military operations of the future."

The Caribou is designed to operate off short, rough fields or improvised strips, carrying a 3-ton payload, and have a 1,400 mile maximum range. The airplane has the ability to fly at a low speed of 70 miles an hour.

BORG-WARNER SALUTES ITS **Ingersoll** DIVISIONS

The first Ingersoll plant, at Sandoval, Illinois
as it appeared in 1899

1884 1959

On Their 75th Anniversary

BORG-WARNER CORPORATION

ENGINEERING B-W PRODUCTION

Ingersoll *Kalamazoo Division*

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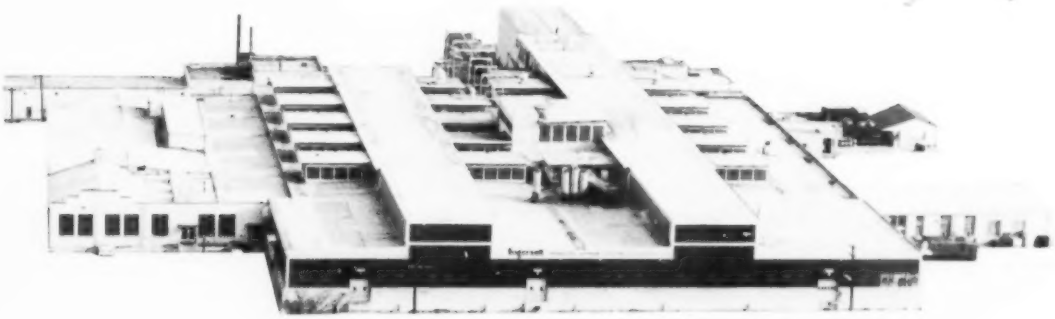
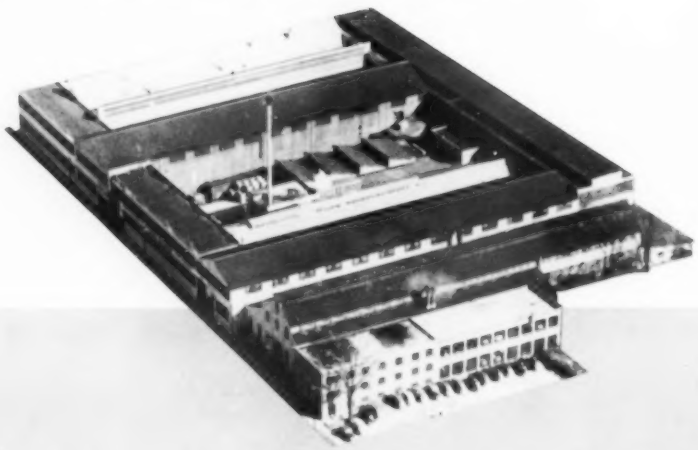


The extensive engineering and production facilities of Ingersoll Kalamazoo Division are located at Kalamazoo, Michigan. North Plant, above; Vine Street Plant, at right.



In 1884, with a handful of employees and a small factory, Stephen A. Ingersoll founded the company that today includes four separate Borg-Warner Divisions, and the management and operation of a B-W subsidiary.

During these 75 years the Ingersoll employee force has grown to several thousand; manufacturing facilities have expanded to seven modern plants with approximately 2,000,000 square feet of space; and extensive product diversification now serves many industries.

Ingersoll Kalamazoo Division had its origin in 1937 when Borg-Warner acquired the facilities of the U. S. Pressed Steel Company. Originally producing automotive stampings, the Division has for many years served the Navy and Marine Corps as design agent, prototype development and test activity, central procurement agent, and lead construction yard for the production of LVT amphibious assault vehicles.

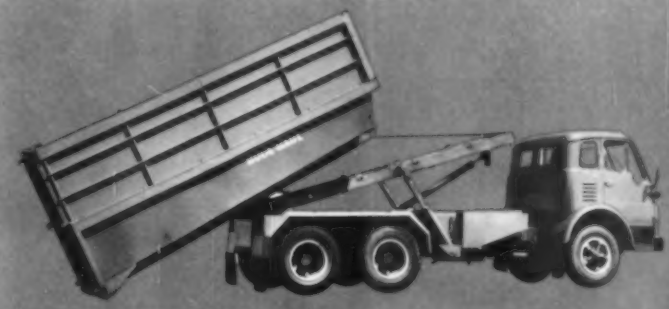
In addition, Ingersoll Kalamazoo today produces rocket motor cases and boosters for the nation's guided missile program; the "Load Lugger," "Huge Haul" and other materials handling products; and a new type military amphibious vehicle designed, developed and engineered by Ingersoll for the Army Transportation Corps.

Back of all these products is the continuing Borg-Warner aim: "Design it better—make it better"—a tradition that benefits almost every American every day.

DESIGN IT BETTER INGERSOLL KALAMAZOO B-W BORG-WARNER *MAKE IT BETTER*

Rocket Motor Cases have been produced by Ingersoll Kalamazoo for many years. The four boosters and sustainer motor case of the Nike Hercules Missile are produced for the Army.

A product of Ingersoll Kalamazoo Division, the Load Lugger System of materials handling consists of detachable steel containers handled by a truck equipped with Load Lugger hoist. Loaded container is picked up, placed on truck bed, and transported to destination. With special containers, the Load Lugger handles all types of materials—solids, liquids or gases.



Similar in principle to the Load Lugger, Ingersoll's Huge Haul handles large quantities of waste, scrap, other bulk materials. Hoist capacity is 30,000 lbs.; containers handle up to 40 cu. yds.

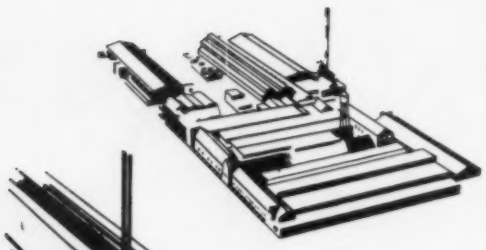
The LARC-5 is a new type military amphibious craft designed, engineered and built by Ingersoll Kalamazoo for the Army Transportation Corps. Carrying a 5-ton cargo, it travels through the water at 10 miles per hour, on land at 25 miles per hour.

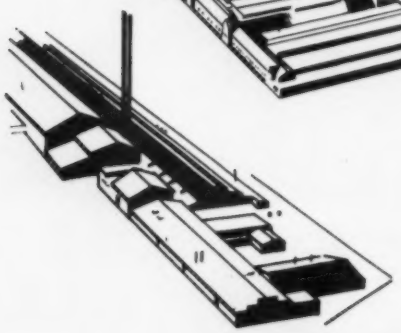
A powerful landing or combat weapon, the LVT was designed and developed by Ingersoll Kalamazoo for the Marine Corps. It has been made in two forms—as an amphibious combat tank, and as a personnel and cargo carrier.

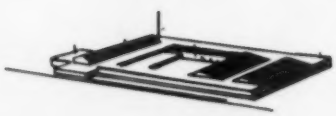
The Challenge . . . *and the Promise*

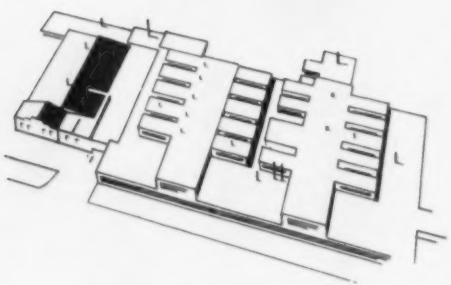
Recognizing that the achievements of the past are but a guide to the future, the Ingersoll Divisions of Borg-Warner reaffirm their continued adherence to the principles established by their founder—integrity of purpose, quality of product, and dedicated service. This is the Ingersoll challenge . . . and the Ingersoll promise.

THESE ARE THE INGERSOLL DIVISIONS OF BORG-WARNER









INGERSOLL PRODUCTS, Chicago, Illinois. Plow and harrow discs and coulter blades, pressed steel implement wheels, tractor seats and instrument panels, and other farm implement parts; tapered discs for truck wheels; formed and deep drawn steel stampings; raw and porcelain enameled washing machine tubs and components; porcelain enameled steel sinks and bathtubs; solid fuel furnaces; industrial cranes and hoists.

INGERSOLL STEEL, New Castle, Indiana. Open hearth and electric furnace high carbon and alloy steels; soft center plow steels; stainless and heat-resisting steels; stainless-clad steel sheets; forging quality electric furnace alloy steel ingots; high speed hack saw steels; agricultural flat and formed discs; automotive and tractor clutch discs; hand shovels, spades and scoops; lightweight aluminum scoops; stainless steel shovels and scoops.

INGERSOLL KALAMAZOO, Kalamazoo, Michigan. Materials handling equipment (Load Lugger System); special vehicles for the military; rocket motor cases and guided missile boosters; design agents for LVT amphibian landing vehicles.

REFLECTAL CORPORATION, Chicago, Illinois. (Ingersoll managed). Alfol aluminum foil reflective insulation for buildings; asbestos insulation; jacketing; KoolShade sun screen; Betocel cellular insulating concrete.

INGERSOLL-HUMPHRYES, Mansfield, Ohio. Enameled cast iron and steel bathtubs, sinks and lavatories; vitreous china water closets and lavatories; plumbing fixture fittings.

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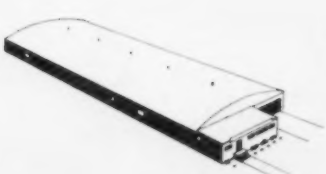
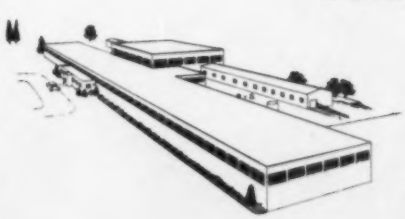
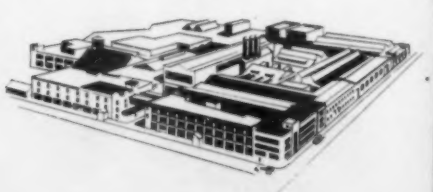






SPACE ARMAMENT

Space Projects

Space project and program names seem to be sufficiently stable to report, although cancellations and reorientation of requirements could make sudden changes. The National Aeronautics and Space Administration has planned a series of increasingly powerful launching rockets from Delta, Scout, Vega, Centaur, up to the giant Nova.

In other words, NASA in its first years will continue to use the rockets developed by the armed services, such as Thor and Jupiter first stages, to conduct its own experiments. Eventually the Defense Department will be looking to NASA for the advanced launchers now under development by that activity although some stages in these rockets will be from present military missiles.

The Advanced Research Projects Agency directs the Saturn project being developed by Army Ordnance—a 1.5-million-pound-thrust 3-stage launching rocket and probably the first big one that will be available.

Right now ARPA is in the process of turning over to the services the projects noted in Defense Highlights in this issue —Samos, Midas, Transit, and Courier. The latter project is part of ARPA's Notus program for communication satellites that also includes Steer for polar orbiting and Decree for equatorial orbiting.

In addition, ARPA continues control of Shepherd, a satellite-detection fence under development by the Army and Navy. It also has revealed recently a program designation, Suzano, to develop orbital space platforms as advanced bases for probing lunar and planetary space.

In other lunar-oriented work, a $150,000 contract for studies of the problem of soft lunar landings went to the Army Ordnance Missile Command. Massachusetts Institute of Technology, under a $100,000 contract, is to design and build a prototype instrument to measure the density of plasma (electrified gases) between the earth and the moon and particularly around the moon.

In the same area, two contracts went to the Naval Research Laboratory. One is for instrumentation to measure the natural radioactivity of the moon; the other is for a lunar data-acquisition and recording system.

In engine research, a $390,000 contract went to General Electric Company for a study into what propulsion engineers call a "plug-nozzle" engine. Most rocket engines employ a cone-shaped nozzle through which fire and exhaust gases escape. In theory, the plug-nozzle concept "spikes" the conventional central opening, and combustion takes place in a ring of cells about the rocket's base.

Exhaust gases would follow the contour of the conic-shaped spike in leaving the combustion chambers and push away from the spiked surface depending on the altitude. The idea is that the departure of the gases would be self-adjusting according to altitude and thereby increase the rocket's efficiency. Preliminary studies suggest such a concept could increase low-altitude rocket efficiency substantially.

Plug-nozzle advocates say the concept would be best employed in the initial booster stage of a multistage rocket. If successful, the study may provide information for the scaling of rocket engines to the multimillion-pound-thrust category.

The University of Minnesota received a contract to build a life-support system using plants (probably algae) to generate oxygen for human breathing on extended space flights. The long-range study is to develop a prototype system.

Hughes Aircraft Corporation was awarded a $200,000 contract for the design and construction of an atomic clock using ammonia vapor which may be employed to test Einstein's theory of relativity regarding time variations in space.

Moon Probe Progress

Contracts for an instrument to probe the surface of the moon and the study of a new rocket engine concept are among nearly $16 million worth of contracts recently awarded by NASA. Under such contracts, scientists at Columbia University and the California Institute of Technology will collaborate on the construction of a "lunar seismograph."

Such a "moonquake" detection system would provide a firsthand means of studying the make-up and crust activity, if any, of the moon. Information on the kinds of rock there and details as to the size and velocity of meteorites hitting the moon are some of the aims of the project. This sort of information would aid greatly in the study of other planets as well.

Stable Space Flights

Interplanetary navigation was brought closer to reality with the disclosure that General Electric scientists at its Missile and Space Vehicle Department, Philadelphia, Pa., have successfully tested, in outer space, a new system for navigating space vehicles.

The test occurred during a routine Thor IRBM flight from Cape Canaveral. The new space navigation system uses infrared to locate the horizon, which is defined here as the curvature of the earth at space altitudes, and a special sensing device to locate and track on the sun. The complete space navigation system is self-contained in a reentry vehicle and is immune to all natural disturbances.

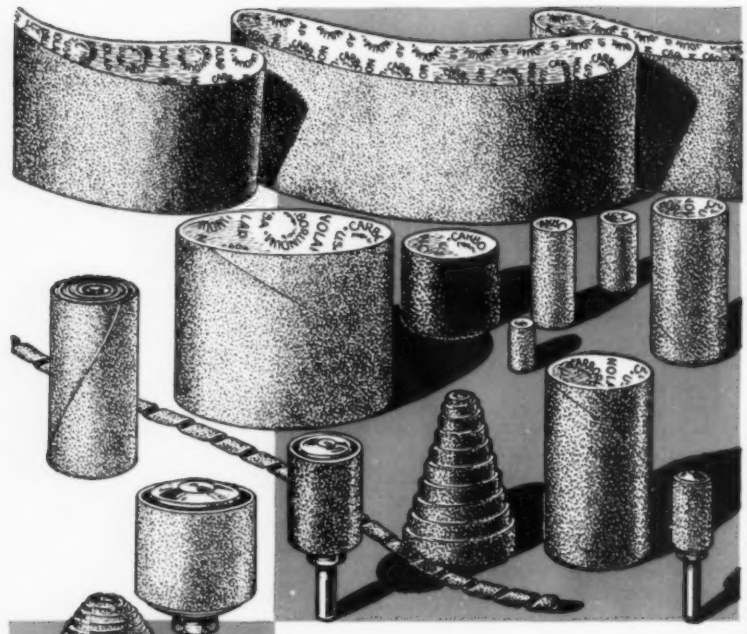
During this Thor flight a special camera also was mounted in a recoverable data capsule carried in the aft end of the nose cone. This camera made a continuous visual record of the successful test of the special navigation system from about 100 miles to the peak altitude of 316 miles and part of the downward leg of the trajectory. The camera acted as a backup to the normal telemetry system which also verified the successful outer-space flight test.

Movies taken from the reentry vehicle showed the whole flight sequence from separation of the nose cone and rocket booster to reentry. The movie-taking technique was the same as that used on May 12th when a similar nose cone took the first movies ever made from 300 miles up.

Stable space flight must be achieved before real space navigation is possible. It is the second step following the ability to hurl a vehicle into space. It would be impossible to change the direction of a space vehicle to a desired new course if the vehicle were tumbling at random through space.

During the stable flight of the Thor nose cone two wide-angle infrared sensors continuously scan the earth and locate the horizon. They operate on the basic principle that the earth radiates a large amount of infrared light and that space contains very little infrared. When the sensor detects a combination of high and low readings it is looking at the horizon. If the vehicle starts to veer from this position, the infrared system senses the change in the earth-space relationship and the vehicle is thrust back into position with compressed-gas jets.

The infrared system alone will not completely stabilize the nose cone because it could stand stable on its tail yet spin like a top while the horizon remained level.



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Space Armament (Contd.)

The sun tracker provides another "fix" or point of reference to eliminate possible spinning motion. The sun sensor is located behind a slit in the afterbody of the reentry vehicle. After the vehicle separates from the rocket, the infrared system is turned on, and the vehicle is made stable to the horizon. Then jet nozzles release compressed gas to revolve the vehicle slowly until the sun tracker is facing the sun. Once the tracker picks up the sun it holds it.

The sun's rays are optically focused on special heat-sensitive materials whose electrical resistance changes when exposed. If the vehicle starts to move in a spinning motion, this will start to turn the tracker away from the sun and the voltage will change. When this happens, the jet nozzles immediately apply a correcting thrust.

A special computer carried in the nose cone is at the heart of the system that receives the information picked up by the difference sensors and translates this information into corrective action via the jet nozzles.

The movies that were taken during the flight were recovered in a data capsule that was ejected from the nose cone after reentry into the earth's atmosphere. The nose cone itself is not designed for recovery.

Experimental Cloud

A Nike-Asp sounding rocket designed to provide basic geophysical information on wind activity was launched from the National Aeronautics and Space Administration's Wallops Station, Va., and ejected a trail of sodium vapor which began at an altitude of about 50 miles and extended to a peak of about 150 miles.

In the early morning light it produced a huge orange-yellow cloud visible over a large area of the Eastern seaboard. The cloud then drifted inland and was seen as far south as Vero Beach, Fla., and as far north as Pittsburgh and Dayton. Scientists photographed the phenomenon from five stations, and from the data obtained they will be better able to study wind velocities and directions plus diffusion in the upper atmosphere.

The 27-foot Nike-Asp is a 2-stage solid-fuel rocket using the Army's Nike as first stage and the Cooper Development Corporation Asp as the second stage. The Nike-Asp has a gross take-off weight of 1,550 pounds. The 75-pound payload contained about 10 pounds of sodium pellets mixed with a thermite compound. The sodium-thermite mixture burned, and the resultant exhaust caused the vapor trail and cloud.

Project Saturn

Selection of second and third stages for the multistage Project Saturn space ve-

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that says
"GO" or "NO GO"

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APCHE (Automatic Programmed Checkout Equipment) is a solid-state, universal, high-speed, highly reliable, compact general-purpose tester designed especially for automatic checkout of aircraft, missile and space systems and their supporting systems. In its various versions (differing in input media, size and weight) APCHE installations may be fixed, mobile, airborne or submarineborne. APCHE was designed and is being produced as a part of RCA's ground support electronics subcontract from the Convair (Astronautics) Division of General Dynamics Corporation, prime contractor for the ATLAS Intercontinental Ballistic Missile.

The system being supplied to Convair for the ATLAS Program includes a console and four rack cabinets providing both analog and discrete test functions with a resulting printed and GO-NO GO indication. As a product of RCA's Missile Electronics and Controls Department, Burlington, Massachusetts, APCHE is one of the latest RCA developments in the field of military weapon readiness equipments.

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hicle were announced recently by the Advanced Research Projects Agency of the Department of Defense.

A modified first stage of the 2-stage Titan intercontinental ballistic missile has been chosen for the second stage of the Army-developed Saturn vehicle. The Titan is being developed for the Air Force by the Martin Company. The third stage will be the new Centaur rocket under development by the Pratt & Whitney Division of United Aircraft Corporation and the Convair Division of General Dynamics Corporation.

The objective of Project Saturn is to provide by 1962-1963 an efficient and reliable system for lifting multiton loads into high orbit around the earth and into deep space.

The Saturn's first-stage booster will be a cluster of eight H-1 rocket engines developed by Rocketdyne, a Division of North American Aviation, Inc. The 3-stage Saturn will weigh approximately 580 tons at lift-off, of which about 500 tons will be propellent fuels and oxidizers. It will stand about 200 feet tall, nearly half as high as the Washington Monument. A fourth stage, as yet unselected, may be added later for specific missions.

The first-stage cluster of H-1 engines will be about 75 feet tall, 22 feet in diameter, and will produce about 1,500,000 pounds of thrust at lift-off. The modified Titan second stage will be somewhat longer than the regular 54 feet and will be 10 feet in diameter. Using the same fuel as the first-stage booster, it will provide a thrust of 360,000 pounds. The third-stage Centaur will use 2 rocket engines with a combined thrust of 30,000 pounds and will be 10 feet in diameter.

The vehicle will use an all-inertial guidance system. This system will automatically compensate for deviations resulting from loss of thrust should one of the first-stage booster engines fail to function.

Satellite Pinpointed

The ability of the Army Ballistic Missile Agency to pinpoint the time position of the Army Explorer IV satellite to within one minute in space enabled Project Argus officials to obtain far more useful data on an atomic blast about 300 miles above the earth.

ABMA, an element of the Army Ordnance Missile Command, fabricated and launched Explorer IV as a part of Project Argus. Preliminary evaluation of data collected during the first two Argus firings on August 27 and 30, 1958, indicated the possibility that the instrumentation ship, U.S.S. ALBEMARLE, was not in the proper location to obtain the full effect of these Argus shots.

To confirm these suspicions, ABMA conducted a study to determine the accuracy of the satellite-prediction data published by other agencies. This study revealed a time discrepancy in the prediction data of about fifteen minutes with regard to the expected position of the satellite in space at the time of the third Argus shot, due on September 6th. Attempting to reduce this discrepancy, Army Ballistic Missile Agency personnel studied and evaluated data obtained from an ABMA instrumentation station at Redstone Arsenal by personnel of the Agency's Research Projects and Computation Laboratories.

Results of this data study reduced the satellite's time-position error to about one minute for the firing time under consideration. These new data showed the U.S.S. ALBEMARLE to be out of position by some 200 miles, and the instrumentation ship was relocated to an optimum position for the final Argus shot to assist in the confirmation of the Christofilos theory.

Nose Cone Recovery

The Air Force Atlas nose cone recovered from the South Atlantic after it was launched last July 20th was the biggest reentry vehicle to be flown in the free world up to that time. Returned to Cape Canaveral aboard a special recovery ship, the General Electric-built vehicle was the first full-scale advance-design nose cone to travel intercontinental range and the first ICBM-range reentry vehicle of this size designed to be recovered.

This was one of a series of experimental nose cones leading to the second-generation ablating type of ICBM operational reentry vehicles. The shape of the vehicle is an elongated cone with a rounded nose. Constructed of relatively lightweight "ablation" materials, it is over twelve feet long. Current Thor and Atlas nose cones are of the heat-sink principle in which a heat shield is able to absorb the terrific temperatures of reentry.

The recovery system, which was developed in cooperation with the Cook Company of Chicago, operates as follows:

1. After reentry, a rear cover is ejected from the vehicle and a parachute is deployed.

2. Before water impact a balloon is inflated which supports the vehicle in the water at the end of the parachute shroud lines.

3. After water impact, a radio transmitter in the nose cone is activated, a flashing light is turned on, and a dye marker device discolors the surrounding water. Aircraft and ships in the area, guided by these location devices, find and retrieve the reentry vehicle.

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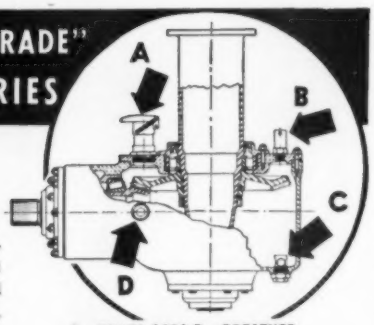

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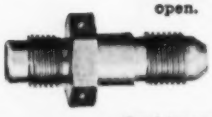

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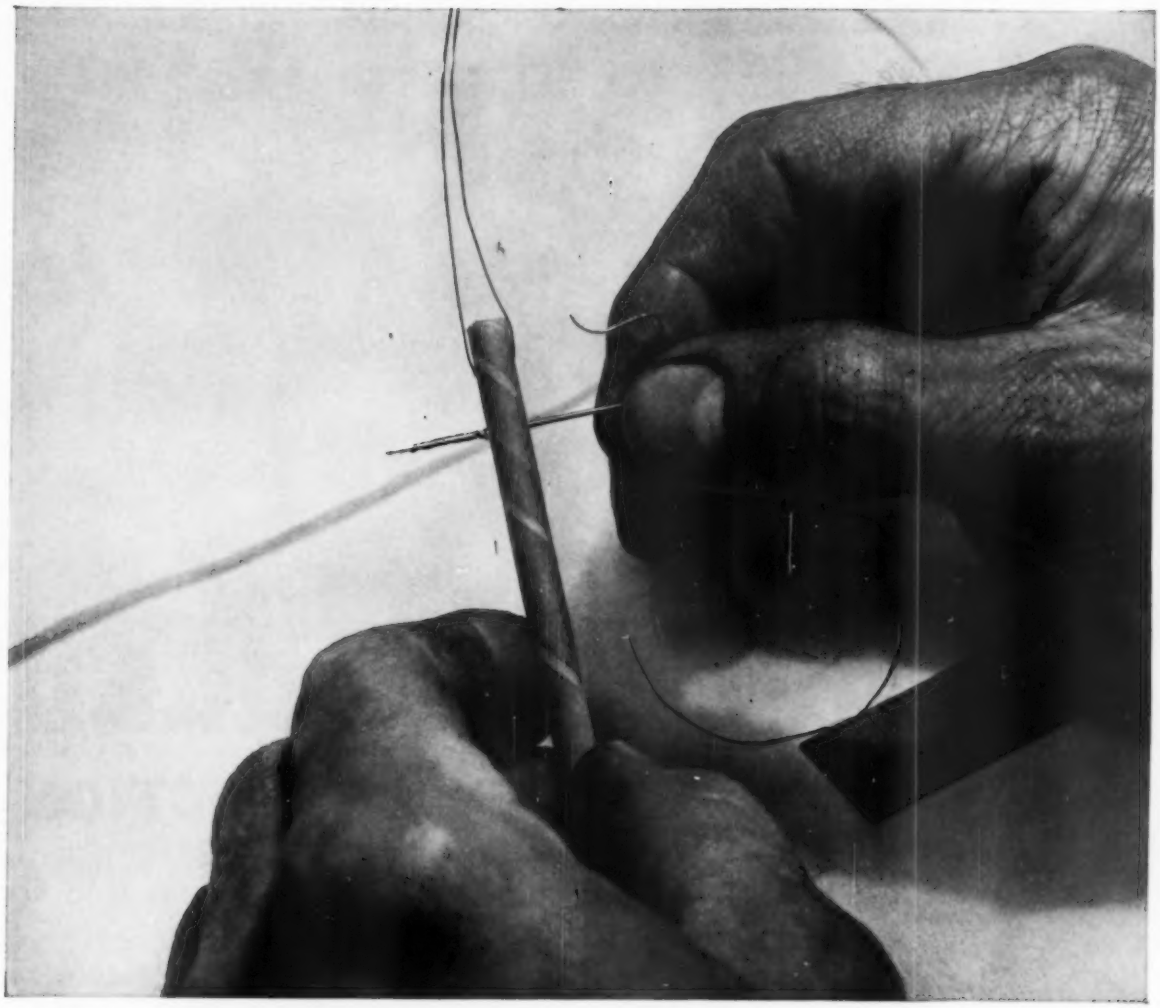

How to Test a Solid Rocket Motor

In the early stages of research for new or improved propellants incongruous combinations of materials are often brought together in the chemistry laboratory—in this case, a common drinking straw, a strand of copper wire, a small batch of propellant and a sewing needle. The work shown here is a step in an experiment to test burning characteristics of a new high-energy propellant formula. The propellant, having been extruded into the straw, is threaded with a strand of copper wire. Later the "motor" is hooked into a specially designed apparatus that ignites the propellant and records and evaluates its performance.

From the igniting of grams of fuel in the chemistry labs to the test-firing of huge motors on the 2,000,000 lb. thrust test stands at THIOKOL's Utah facilities, research paces and supports every phase of the design, development and production of a rocket powerplant.

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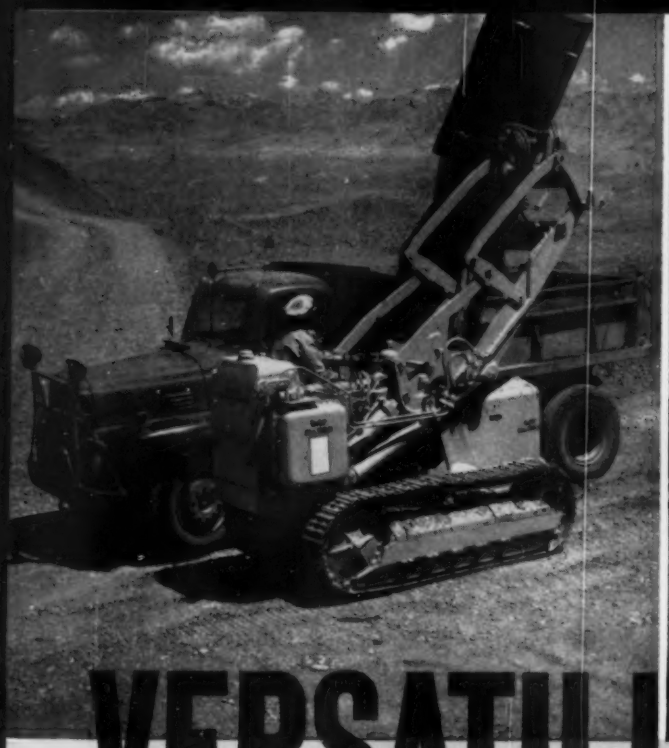

VERSATILITY SPEED

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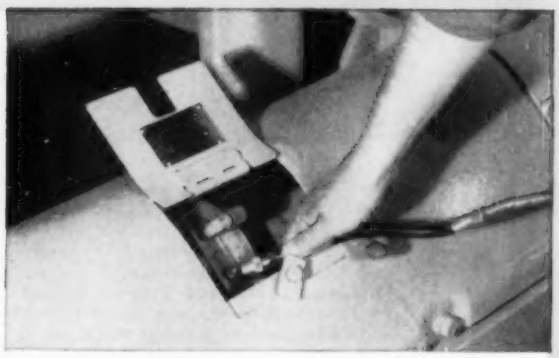
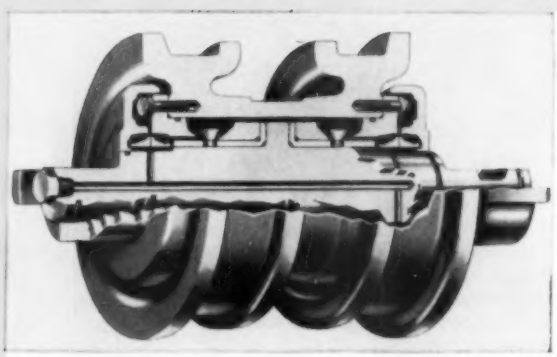
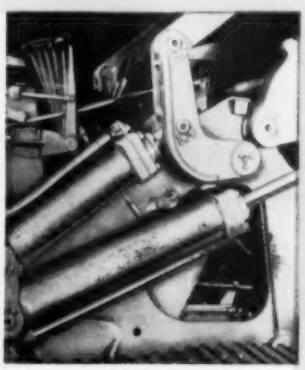


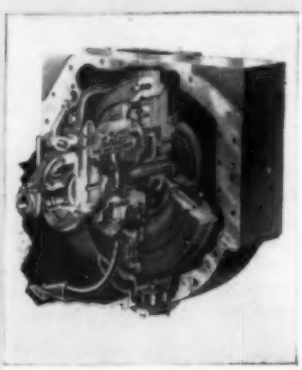
HYDRAULIC TRACK ADJUSTERS standard on the No. 977 and No. 955 —optional on the No. 933. An ordinary grease gun is all that's needed to adjust tracks. Just open the inspection door and apply a few strokes. The hydraulic cylinder does the rest.



LIFETIME LUBRICATED ROLLERS. They need no lubrication servicing until rebuilding. Heat-dissipating oil lubricant is retained by dirtproof floating-ring seal. Eliminate on-the-job roller lubrication. Keep machines on-the-go for longer periods of time.

SMOOTH-FLOW BUCKET CONTROL LEVER. The inside lever is pulled back, lifting the load. It locks in this position until it is kicked out at maximum height by the lift cylinder and linkage. After dumping, both levers are pushed forward. The bucket lowers but only tilts back to an adjustable, preset digging position. Linkage then kicks the outside lever, stopping the bucket tilt.





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Traxcavators are built to last. They have a heavy steel main frame, welded into a one-piece unit. Box construction track roller frame absorbs the loads and stresses of tough treatment. Lift arms are made to stand up under the strain of heaviest digging conditions.

Traxcavators give you fast action and ease of operation. Excellent stability and balance give better control of the machine. A fast hydraulic system cuts cycle time and increases maneuverability even in close quarters. Visibility is excellent. The high seat puts the operator on "top" of the work. Operator's compartment is uncluttered. Tractor controls are conveniently located for handling ease. Bucket controls are at the right armrest . . . closely spaced for dual operation with one hand.

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MATERIALS PROGRESS

George S. Brady

Private Industrial Research.—It often has been said that the soundness of our economy rather than initial military might will be the determining factor for success in a major war. What we get out of the huge defense expenditures that will be of permanent benefit to the whole economy, therefore, should be some measure of that soundness. We refer, of course, only to material improvements, since the worldwide training of men and other benefits of a social nature are not easily measurable.

Since World War II, a very large proportion of the technical improvements in civilian products has been directly traceable to the developments of military research—research which, because of its great cost, might have been strung out over many years if it had not been quickened by military needs.

The 1960 "defense" budget contains $3.38 billion for research and development. This direct research constitutes about eight per cent of the total defense spending for the fiscal year, but it is not all. Even after a production contract is given out, most military equipment is subject to constant design changes which stimulate research on the part of the manufacturers.

It is difficult to measure the research of private industry, and the figures given for it are of doubtful value. A recent McGraw-Hill study of industrial research shows some interesting points. The big companies' figures include only exploratory research, while the smaller companies are inclined to include design, engineering, and technical services, and the figures are not comparable.

Drug companies top the list, with six cents of the sales dollar going into research, and paper is near the bottom with less than half a cent of the sales dollar going for research. But these figures, also, are not comparable because most of the research on paper is not done at the paper mills but at the plants producing the materials that go into the paper.

The study also shows why private research is concentrated mostly in the big companies. Modern basic research requires expensive equipment, and the services of a laboratory man cost twice as much as they did fifteen years ago. According to *Du Pont* scientists, only one project in twenty ever comes to commercial fruition, and it normally takes an average of seven years from the test tube to the product sale.

The research pioneer is often at a sales disadvantage because, after he has developed a new material or a new process at great expense, even though he gets a patent the basic principles are exposed to competitors who can then develop similar products with but little more research.

Educators have been deploring the fact that less than 30,000 people in the United States, only 0.011 per cent of the population, are engaged in basic research. But that percentage is high compared with the scant few who were engaged in basic research problems in the previous century when we made such tremendous advances in chemistry, physics, metallurgy, and in practical applications in electrical and other manufacturing.

There already is much evidence that we are unable to utilize scientific knowledge as fast as it is now being developed. It usually requires a scientist to unfold basic data, but it does not

Colonel Brady is a consulting engineer, author, and editor, Washington, D. C. He is a well-known authority in the field of materials, and his "Materials Handbook" is a recognized source of information on the subject.

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Materials Progress (Contd.)

require a scientist to utilize the information. This is done by the vastly greater number of people in the technical services and in production.

A serious advancing problem today is an adequate coordination and dissemination of research findings. The majority of basic research papers which appear in scientific journals and at scientific meetings come from researchers in relatively few companies. In fact, most of the papers last year were from less than ten companies. These papers, in general, are highly technical and are for other scientists.

Other large companies get out development résumés by news bureaus in more popular style for the trade press which serves the manufacturing industries. The past weakness of this system has been in the scarcity of technically trained newsmen capable of interpreting the scientific knowledge in usable terms, but it is the phase that will need greatest development if we are to derive maximum benefit from our costly research.

With almost the sole exception of the chemical industries, which are relatively new and have not lost their youthful vigor, a high proportion of basic research discoveries has been coming from the materials-consuming industries rather than from the producers of the materials. A *Bell Telephone Laboratories* executive answered a query about this in these words: "We know more about our problems than any supplier would be willing to find out." It is, perhaps, for this reason that *Sylvania Electric Products, Inc.*, set up for basic research on ceramics and *Westinghouse Electric Corporation* set up an expensive laboratory for research into solid physics of metals.

Super Hydraulic Fluid.—In the building of the X-15 manned rocket craft, *North American Aviation* set up advance requirements for a hydraulic fluid to actuate the power steering. The engineers specified that the fluid must not be viscous at low temperatures down to minus 65 degrees Fahrenheit and must be sufficiently viscous at elevated temperatures to 450 degrees to give proper lubrication without leakage. It also was required to have a low vapor pressure to prevent vapor pockets or excessive evaporation. No such fluid was found on the market. Developed by the *California Research Corporation* and the Air Force, a fluid meeting the specifications is now being commercialized as Oronite 8515.

Growing Semiconductor Crystals.—Under another Air Force research contract the tedious and costly process of growing semiconductor crystal boules and cutting into thin slices has been eliminated by *Westinghouse*. The new process grows dendrite crystals of germanium rapidly in one direction in continuous thin strips ⅛-inch wide. The semiconductor device is then mounted directly on the strip, and the strip is cut up into semiconductors which have superior uniform physical characteristics.

Tantalum Research.—The Navy Bureau of Ordnance has given a contract to the *National Research Corporation*, Cambridge, Mass., for research and development of tantalum and tantalum-tungsten alloys, particularly for nozzles and other parts of rockets. Flame temperatures at a rocket nozzle may reach as high as 6,000 degrees Fahrenheit. Tantalum-tungsten alloys already tested have shown good strength and erosion resistance at temperatures above 4,000 degrees.

Some tantalum-tungsten alloys developed by *Stauffer-Temescal* for rocket motor parts have melting points from 5,430 to 6,150 degrees and retain a tensile strength of 15,000 pounds per square inch at 4,500 degrees. *Du Pont* also is setting up a metallurgical development center in Baltimore for research studies on tantalum, columbium, zirconium, and tungsten.

Beryllium Flying Saucer.—The 72-inch saucer-shaped beryllium outside floor of the Project Mercury manned rocket capsule was produced for the McDonnell Aircraft Corporation by the

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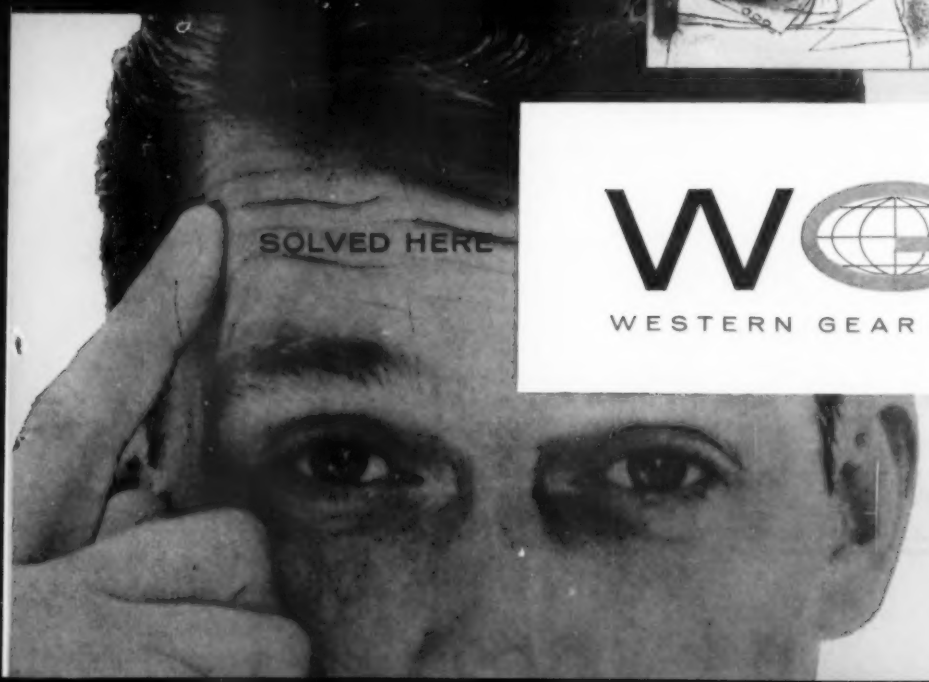

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Materials Progress (Contd.)

materials producers, *Brush Beryllium Company* and *Aluminum Company of America*. The initial billet, sixty-two inches in diameter, was hot-pressed by powder-metallurgy technique by Brush. After preliminary machining it was steel-jacketed, heated to about 2,000 degrees Fahrenheit, and squeezed in a preheated die in Alcoa's 50,000-ton press into the saucer shape, 80 inches in diameter and 3 inches thick, ready for machining.

Beryllium was chosen because of its high heat-absorption ability. It is stated that a rocket reentering the atmosphere at 18,000 miles an hour at an angle of 2 degrees from the horizontal from an elevation of 75 miles would reach a surface temperature of 4,750 degrees Fahrenheit. This is an indication of how high temperatures generated by air friction at high speeds require new materials that will withstand heat or absorb and dissipate it rapidly.

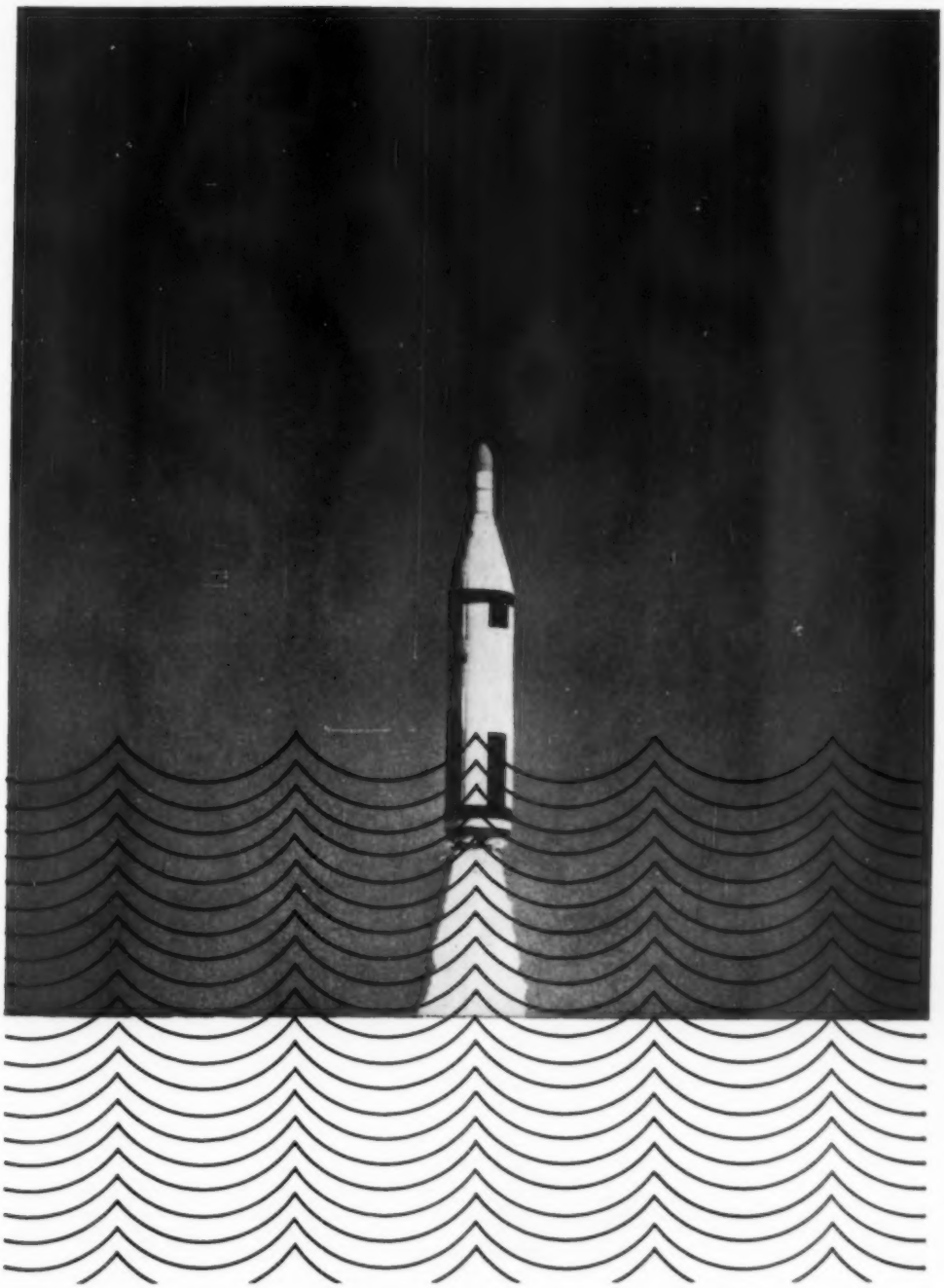
Aluminum Model Engine.—The all-aluminum miniature engines for model airplanes, built by *Bedford Products, Ltd.*, Watford, England, are typical of English precision workmanship and materials selection applied to ordinary commercial products. Engine parts, except the connecting rod which is forged of aluminum alloy HF12WP, are of die-cast LM20 aluminum alloy precision-machined. The connecting rod is bored to an accuracy of 0.0002-inch, and no bushing is used. It runs on a 5 per cent chromium steel pin. The 0.750-inch diameter piston is die-cast of LM13 alloy, and the carburetor is cast into the rear crankcase housing. The tiny engine operates on a mixture of nitromethane, nitrobenzine, and methanol, and develops 0.9 bhp. at 18,000 r.p.m., driving a model plane at speeds up to 98 miles an hour.

Lightweight Diesel.—For weight saving in ship construction, *Guinzio, Rossi, & C.*, Turin, Italy, is producing large built-up marine diesel engine frames from aluminum alloy containing 2.5 per cent magnesium. The bed plates are 1.35 inches thick, and the structural plates are ½- and ¾-inch thick. Welding is done with a 3.5 per cent magnesium-aluminum alloy rod.

Heavy-Duty Alloy.—*Kaiser Aluminum & Chemical Corporation* has developed a "5000 Series" of aluminum alloys for heavy-duty structural applications that give equal stiffness in beams with little more than half the weight of steel. The extrusion possibilities of the alloys also give a wider range of shapes to eliminate built-up sections. The alloys contain from 2.7 to 5.1 per cent of magnesium, up to 1 per cent manganese, and 0.10 chromium. Tensile strengths range up to 42,000 pounds per square inch, with elongation of 16 per cent in the soft condition, and up to 50,000 pounds per square inch in the hard tempers. Joint efficiencies up to 100 per cent are obtainable in the welded structures.

Magnesium in Space.—Of the total weight of 1,700 pounds in one of the Discoverer satellites, 600 pounds is magnesium. The skin and fairings are of alloy sheet HM21A-TS, a magnesium-thorium alloy which is serviceable up to 900 degrees Fahrenheit. The 105-inch-diameter fuel tank head, produced by *Missile-Air* for the Army Ballistic Missile Agency, is made of aluminum alloy 5086 and is said to be the largest thick-walled vessel ever spun. It was hydraulically spun from a blank 7/16-inch thick and 139 inches in diameter.

Extruded Beryllium.—*Northrop Corporation* has an Air Force Matériel Command contract to develop methods for extruding beryllium. The requirement is for extruded parts with lengths up to 20 feet that will withstand temperatures from minus 400 to plus 1,400 degrees Fahrenheit. The target for yield strength was set at 60,000 pounds per square inch. Rigid control of the foreign elements in the metal was considered a prime necessity. Round rods and U channels have been made with yield strengths



Avco "primes" America's newest peacemaker — Newest weapon in America's atomic defense is the Navy's submarine-launched missile, Polaris. The critical job of making sure the Polaris detonates on time and on target was handled by Avco's Crosley Division. Arming and fuzing for the Polaris—like the recent development of the Air Force's Titan nose cone—is typical of Avco's role in U. S. missilery.

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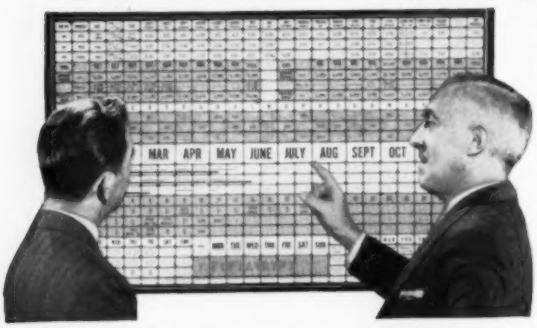

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Materials Progress (Contd.)

up to 80,700 pounds per square inch, but the ductility has been less than target requirements.

New Insulation.—To overcome the temperature limitations of organic insulating materials, *Bell Telephone Laboratories, Inc.*, has been experimenting with a new type of insulation for copper and aluminum wires. A thin film of copper fluoride or aluminum fluoride is deposited on the copper or aluminum by exposing the metal to hydrogen fluoride or elemental fluorine at high temperature. The fluoride films have good resistance to oxidation and have high dielectric strength even at temperatures up to the melting point of the metal conductor.

Ductile Iron Pipe.—A new line of pipe fittings, elbows, tees, and crosses, of the *Pfaudler Company*, Rochester, N. Y., are cast of nodular ductile iron with a minimum tensile strength of 60,000 pounds per square inch. They are glass-coated for chemical resistance and are in sizes from 1½ to 6 inches.

Molecule Synthesized.—*American Potash & Chemical Corporation*, Los Angeles, Calif., has synthesized a boron-phosphorus molecule, a phosphinoborine, which it believes may be the starting point for the production of heat-stable plastics that can withstand temperatures to 750 degrees Fahrenheit. The molecule is described as a linear chain of repeating tetracoordinate phosphorus-boron units with molecular weight of 12,500.

Other companies also have been doing some interesting research on boron. The boron atom has three outer electrons, one less than carbon, and peculiar combinations can be made. For example, when boron is combined with nitrogen, giving a total of eight outer electrons, the resulting material has the chemical similarity of combining two carbon atoms but with totally different physical properties.

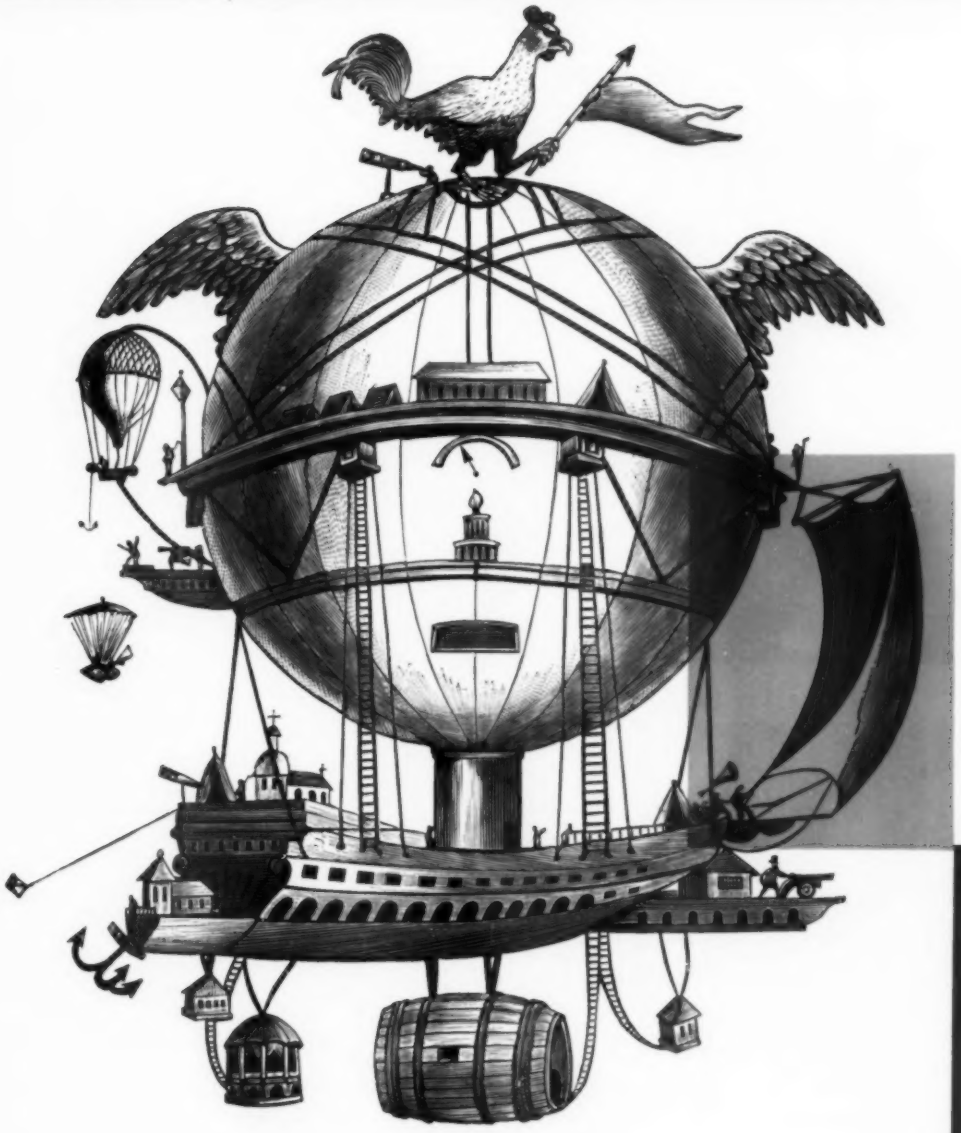
High-Density Plastic.—A new Hi-Mol plastic pipe of the *Carbon Products Corporation*, Aurora, Ohio, is made of a high-density polyethylene with a molecular weight of about 1,000,000 compared with 27,000 for regular polyethylene. It is stated to be the toughest flexible polyethylene so far available and is less expensive than polyvinyl chloride. The pipe will withstand corrosive liquids at temperatures to 150 degrees Fahrenheit without stress cracking.

Besides its use in food-processing and chemical plants, the company is visualizing wide application for cold-water lines. Under regulations effective September 18, 1959, California is now permitting the use of plastic piping for water service lines in houses and industrial buildings.

Hard Lead Gutters.—The gutters of a new building at Duke University are of hard lead (lead with 7 per cent antimony). About 8,000 pounds of hard lead sheet were used, and it was selected because of its long-time corrosion resistance and non-staining of the limestone.

New Wrought Iron.—A new Mn wrought-iron of the *A. M. Byers Company*, Pittsburgh, Pa., is highly deoxidized with low carbon and low phosphorus and containing one per cent manganese. It gives high impact resistance and better low-temperature properties than other wrought irons.

Lateral-Impact Extrusion.—For the production of intricate aluminum shapes, *Aluminum Company of America* engineers have been demonstrating the value of lateral-impact extrusion. The lateral-impact process combines both forging and extrusion, and a hub with spokes made from a cylindrical slug with one stroke has the close tolerances and the physical properties of a forged part.



M. Marey Monge made no attempt to keep imagination in check when he conceived this military balloon in 1800. Complete with sail, the "dream" balloon was supposed to support an army of 4,000 in every way for months at a time. In this wood engraving, Brussel-Smith has included the most minute details of Monge's ambitious project.

IMAGINATION IN SPACE—Since Creation, man has looked out on space. At first, unknowing and incurious; then with the beginnings of understanding; now free and able to explore. Yet to move in space calls for wholly new concepts of energy.

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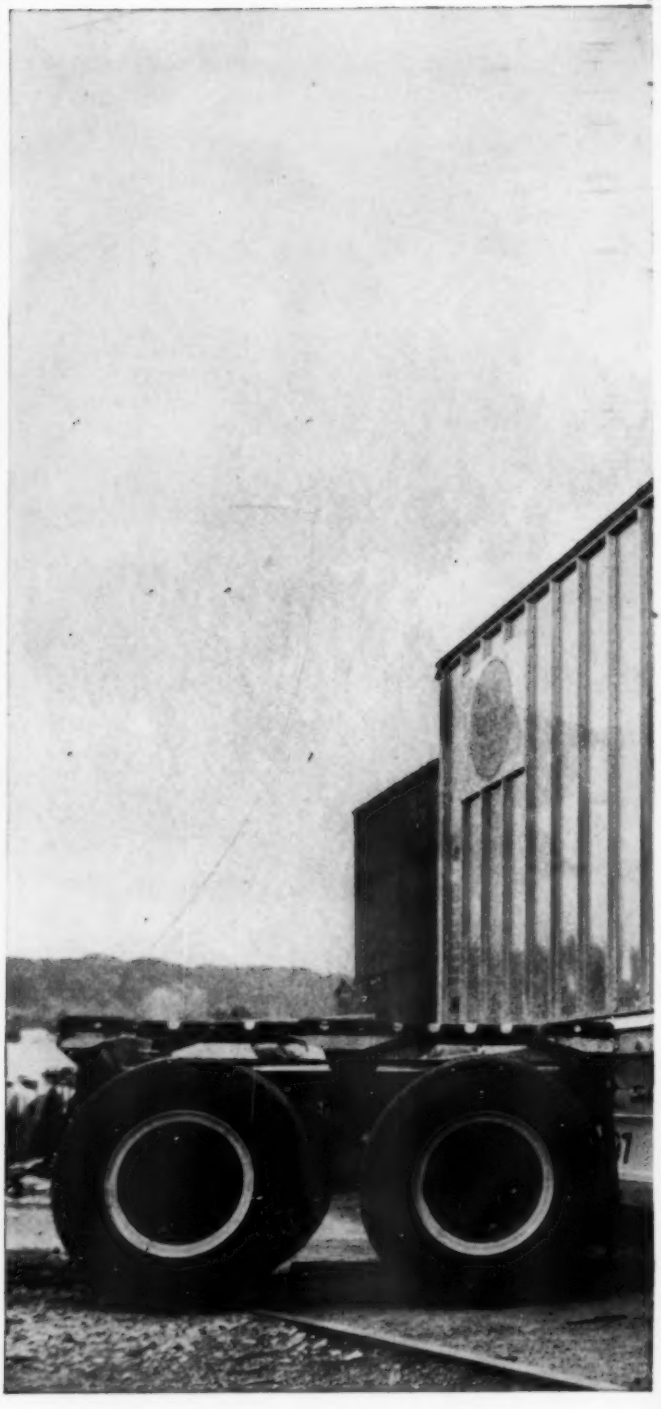

Like other modern railroads, the New York Central carries truck trailers. But they don't take along the wheels. For their truck-train arrangement, they use Flexi-Vans. These advanced trailers slide off their undercarriages and onto special Flexi-Van railroad cars. At their destination, they shift onto a new set of wheels. Result: more payload per pound carried.

Strick Trailer already has manufactured 300 special Flexi-Van railroad cars and 1,000 Flexi-Van trailers for the New York Central. For sideposts, top rails, and bottom rails, they use extruded shapes of Flynn aluminum. Although these parts are lightweight, they provide the strength and rigidity necessary to make up for the absence of a fixed undercarriage.

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RECENT PATENTS

Compiled by Melvin Nord, patent attorney, Detroit, Mich. Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents each.

Hypervelocity Gun.—*U. S. Patent No. 2,882,796. Issued April 21, 1959, to Austin B. J. Clark and Paul T. Boltz:* This invention relates to a cylinder which forms a compression chamber and piston energy absorber for a hypervelocity gun.

As shown in Figure 1, the hypervelocity gun 10 comprises a caliber .50 gun 11, a caliber .30 gun barrel extension 12 connected to the end of the caliber .50 barrel 13 by a cylindrical connector 14, and a vacuum test chamber 19 connected to the end of the caliber .30 gun barrel.

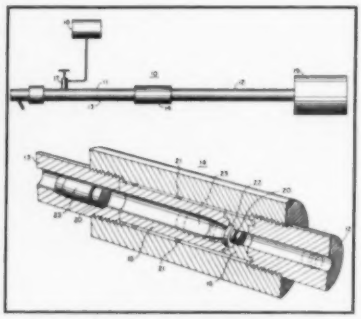


Fig. 1. Details of hypervelocity gun.

A valve 17 is shown connected to the caliber .50 barrel and to a helium supply tank 18 for the purpose of introducing gas into the caliber .50 gun barrel and the compression chamber 15. Situated between the pressure chamber 15 and the caliber .30 gun barrel is a shear projectile holder 16. A shear projectile 22 is shown positioned in the projectile holder, and a piston 23 in the caliber .50 barrel.

When the cartridge is fired, the piston is driven down the caliber .50 barrel and into the compression chamber, compressing the helium gas until the projectile shears from the projectile holder. The piston continues across the compression chamber and expends its energy by plastically deforming itself in the tapered end of the compression chamber and at the same time expanding the compression chamber and the projectile holder into the space between the connector and the compression chamber provided for such expansion. In this manner the piston expends its kinetic energy without damage to either gun barrel or the connector.

The tapered end of the barrel extension provides a piston energy absorber and also permits the end of the piston, on deforming, approximately to fill the entire area of the tapered end portion to force all the gas from behind the shear projectile holder, thereby making use of all the gas possible.

High-velocity guns according to this invention impart velocities of 10,000 to 15,000 ft./sec. to shear projectiles which enables a study of the penetration of small particles traveling around 24,000 ft./sec. or more made by secondary fragments in the splash produced by the impact of a projectile traveling about 12,000 ft./sec.

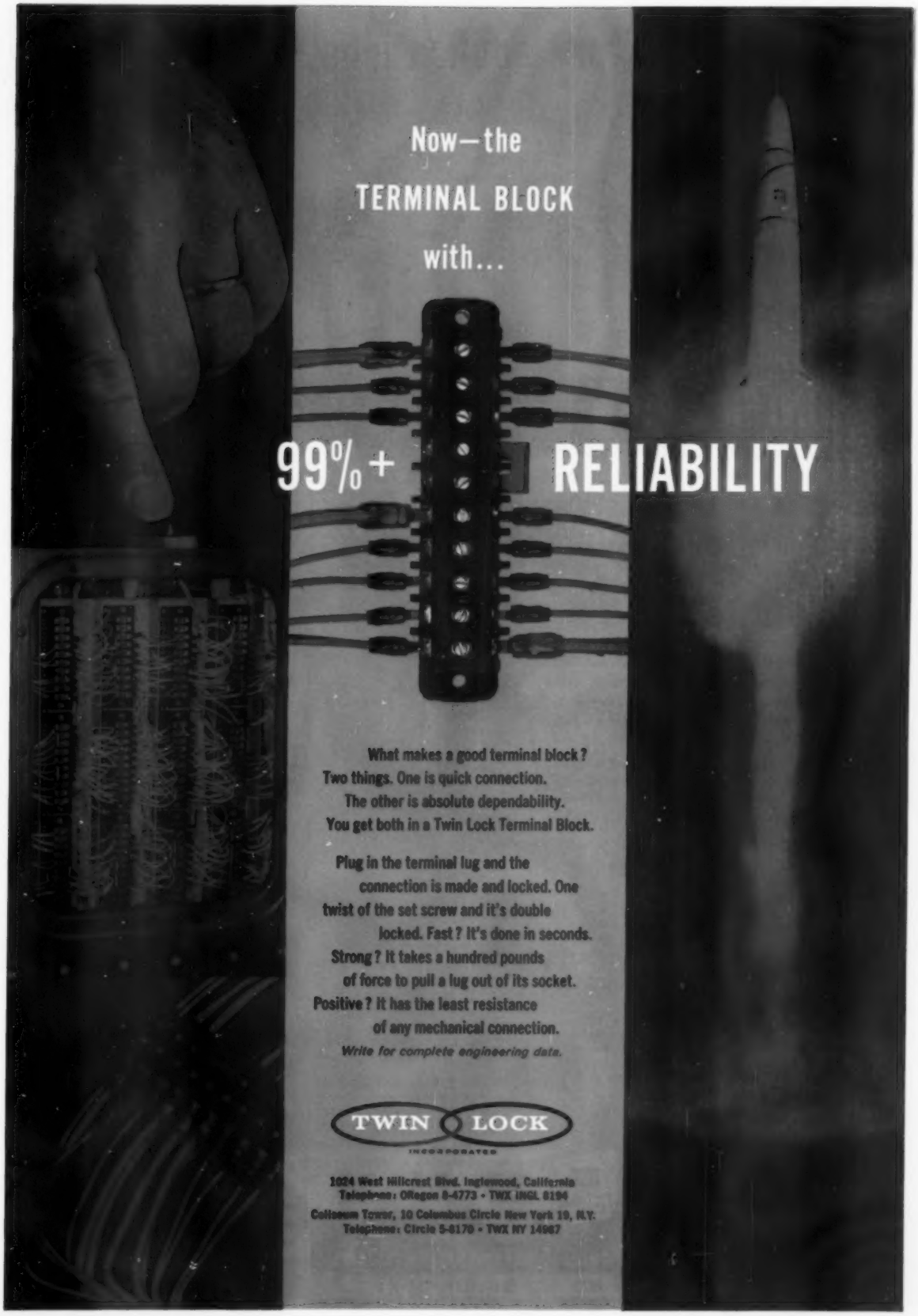
The velocities of secondary fragments produced by impact of a projectile may be as much as five times as fast as the projectile velocity. These very high secondary velocities permit studies of the possible effect of meteor particles on missiles traveling in outer space and the effect of high-velocity particles on impact with different materials or for any desired study.

Sonar Signal Simulator.—*U. S. Patent No. 2,881,535. Issued April 14, 1959, to Robert H. Harwood, Zack D. Reynolds, and Earl G. Hedger. Assigned to Secretary of the Navy:* This invention provides an electronic sonar signal simulator for training purposes. It provides for simulation of initial pulse, reverberations corresponding to various possible sea conditions, and a Doppler-compensated single target echo as returned from craft maneuvering at any reasonable range and speed.

Mine Firing Mechanism.—*U. S. Patent No. 2,881,702. Issued April 14, 1959, to James B. Glennon, Robert H. Park, Wilson R. Maltby, and Charles A. Hobbs:* This invention relates to mine-firing mechanisms of the electromagnetic-induction type in which a changing magnetic field is employed to fire the mine and in which the possibility of detonation by mine-sweeping operations is extremely remote.

In order to establish an effective magnetic field of considerable size about a sweep wire, it is necessary to employ an electric current of such strength that the source of electrical energy is only sufficient to allow the current to be applied to the sweep wire periodically for short periods of time.

In the present invention, the mine-firing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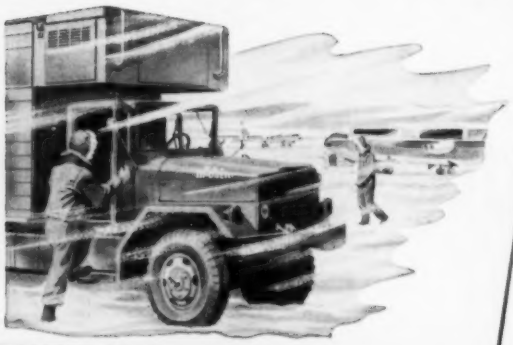
HEAT in military applications



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Recent Patents (Contd.)

mechanism includes certain selecting and time-delay elements in combination with the field-sensing device, so that detonation of the mine is effected only when the magnetic field continues to change for a predetermined period of time, as caused by the movement of a steel vessel.

Proximity Fuze.—*U. S. Patent No. 2,882,823. Issued April 21, 1959, to Joseph Menke and Ernst Doerpinghaus. Assigned to Brinro Limited:* This invention provides an apparatus to be tripped or triggered into operation by variations in infrared radiation. In the daytime, an airplane by stopping the light rays causes a reduction of the radiation intensity. During the night the approach of an airplane produces an increase of this intensity because of the radiation from its engines.

It is not necessary, even in the daytime, for the plane to intercept the sun's rays. In any event, the presence of an airplane increases or decreases the intensity of infrared radiation, and this causes a thyratron to be operated.

Grenade Launcher.—*U. S. Patent No. 2,883,781. Issued April 28, 1959, to Earle M. Harvey. Assigned to the Secretary of the Army:* This invention provides a device attachable to the muzzle of a firearm barrel which suppresses the flash, reduces the recoil, stabilizes the barrel when the firearm is actuated, and also is adapted for launching grenades without any change of parts.

Gases are bled angularly from the barrel to reduce the recoil forces and compensate for barrel climb. The gases are blocked off when the device is used to launch a grenade so that the entire gas pressure at the muzzle of the firearm may act against the grenade for propulsion purposes.

Stability Control for Aircraft.—*U. S. Patent No. 2,885,161. Issued May 5, 1959, to Richard Kerker and Lincoln A. Martin. Assigned to Douglas Aircraft Company:* This invention relates to aircraft having wings incorporating a high degree of sweepback, such as in the case of modern, ultra-high-speed combat aircraft. Such airplanes are notoriously unstable longitudinally, especially at high angles of attack as prevail in landing or take-off.

This unstability has been found to be the result of the sudden formation on the upper surface of the wing, near the leading edge, of an extensive region in which the air stream departs entirely from contact with the wing, returning to the wing surface farther aft. This results in an undesirable increase in lift in this region, setting up a strong positive pitching moment. The present invention solves this difficulty by adding a vertical airflow dam on each wing.

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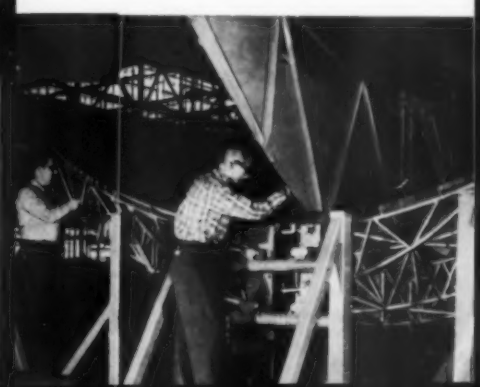
Recently the MPS-16 radar antennas and pedestals were manufactured by Avco/Nashville. Today, Avco/Nashville is at work on the antenna and pedestal of the FPS-26 radar, researched and developed by Avco's Crosley Division, that will stand three stories high and be housed in a radome about 50 feet in diameter. Also in production: very small radar antennas for use in the Mach 3 military aircraft that will be operating in the early 1960's. These use Avcomb, stainless-steel honeycomb.

Radar antennas of the conventional rod type, glass lay-up, and stainless-steel honeycomb are all within the proven capability of Avco/Nashville's engineering and production facilities.

Avco/Nashville has the capacity as well as the capability for more pedestal and antenna work, and invites inquiries from radar prime contractors. Write to: General Sales Manager, Nashville Division, Avco Corporation, Nashville, Tennessee.



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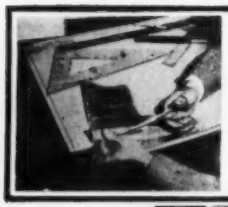

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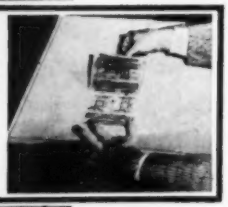

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ROCKETS AND GUIDED MISSILES

Alfred J. Zaehringer

Astronautics.—A full-scale Project Mercury capsule was successfully recovered from the Atlantic Ocean after being fired from an Atlas rocket vehicle and subsequently surviving reentry into the atmosphere. The 9½-foot-long capsule was to have flown 2,000 miles, but a failure in the booster rocket did not give full range. Nevertheless, NASA scientists report that the capsule was in good condition.

Such unmanned ballistic shots and subsequent reentry and recovery are important cogs in perfecting the booster-capsule combination before man takes a ballistic ride. After the preliminary ballistic rides, man will go into orbit.

Explorer VI, a 142-pound spherical satellite, went into orbit on August 7th, the NASA Thor-Able being used for the first time as a satellite launcher. The Thor IRBM with its 150,000-pound-thrust rocket engine served as the first stage. The Able second-stage rocket also was a liquid-propellant engine. Third stage was a solid-propellant combination using glass plastic as the rocket case.

Explorer VI is on a highly elliptical orbit. Closest point to the earth (perigee) is 140 miles while the farthest point (apogee) is 23,000 miles. Dubbed the "paddle-wheel" satellite, it has solar cells on four arms that opened in orbit to convert the sun's energy into electrical power for instruments within the vehicle. Each arm has a bank of 50 solar cells which produce ¼-watt under direct sunlight.

Tests to be performed by Explorer VI are to determine environmental conditions in space and to study the long-range propagation of radio signals. In the latter tests, the telemetry system is designed to transmit signals from nearly fifty million miles in space.

The first Scout all-solid-propellant satellite rocket has been assembled by Chance Vought Aircraft, Inc., for delivery to NASA at Wallops Island, Va. Aerojet-General's Senior is the first stage. An improved Thiokol Sergeant serves as the second stage. A Bureau of Ordnance-Allegany Ballistics Laboratory X-254 fiberglass-plastic motor is the third stage.

The fourth stage is the BuOrd-Allegany X-248 motor. The Scout rocket was assembled in four months. The 70-foot-long Scout is designed to put 200 to 300 pounds into orbit. Operational date is said to be spring 1960.

Missiles.—An Atlas ICBM recently was launched for the first time from Vandenberg Air Force Base, Calif., over the Pacific by a crew of the 1st Ballistic Missile Division, and Atlas is now considered operational by SAC. The first full-powered flight for Atlas was made from Cape Canaveral, Fla., on August 2, 1958. The ICBM made its first full-range flight, a distance of 6,325 miles, on November 28, 1958. The first West Coast firing was on September 9th.

Atlas is boosted by 360,000 pounds of thrust from its liquid oxygen and RP-1 (kerosene-type fuel) propellants. The equivalent of 7½ million horsepower—equal to 4 times the power needed to light the city of Los Angeles—pushes the rocket to a speed of 15,000 miles an hour. Combat troops aimed the Atlas to a spot near Wake Island, some 4,400 miles away.

First shipboard launch of the Polaris was announced by the Navy when the 2-stage, solid-propellant, fleet ballistic missile was fired from the U.S.S. Observation Sound. Polaris, though, is designed to be launched from submarines under the water to targets over 1,000 miles away carrying a nuclear warhead. The Navy expects to have the first operational Polaris mated to the atomic submarine George Washington late in 1960.

Meanwhile, Polaris is being talked about as a potential satellite launcher for orbiting 50-pound payloads. It is being estimated that about 1,000 Polaris missiles will be produced. Each submarine will carry 16 missiles, and a fleet of 40 nuclear-powered missile submersibles has been proposed. Other missiles would be needed for training and spares. It is estimated that each Polaris will cost (less atomic warhead) about $500,000.

Down at the other end of the missile spectrum is the Army Redeye. Convair-Pomona is developing the one-man anti-aircraft weapon under a $6 million contract. Bazookalike, the weapon is about 3 inches in diameter, about 4 feet long, and weighs about 20 pounds. The solid rocket is fired from a shoulder launcher and is designed to protect ground troops against strafing or low-flying aircraft. Initial guidance is by optical means; on launch, the Redeye is guided to its target by infrared.

Another small Army rocket, the Davy

Mr. Zaehringer, president of the American Rocket Company, Wyandotte, Mich., is a recognized authority on astronautics, guided missiles, and jet propulsion.

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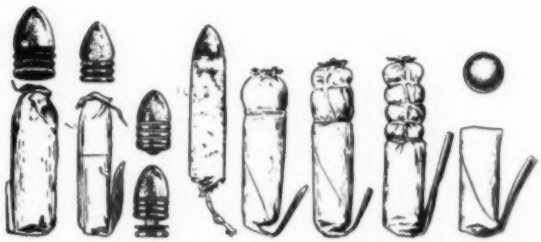

NOTES ON AMMUNITION of the AMERICAN CIVIL WAR

By Col. Berkeley R. Lewis

This, the second in a series of monographs on Civil War armament, is a detailed study of the small-arms and artillery ammunition used by both sides in that conflict. It contains official lists of ammunition types and quantities, along with descriptions, charts, and authentic drawings. Included are service test data, with comments on characteristics, plus a discussion on powder manufacture.

In this précis, Col. Berkeley R. Lewis (Ordnance Corps, United States Army, Retired), covers a period of many advances in ammunition—advances which greatly influenced military arms and tactics. Colonel Lewis, a well-known weapons historian and small-arms expert, is author of "Small Arms and Ammunition in the United States Service."

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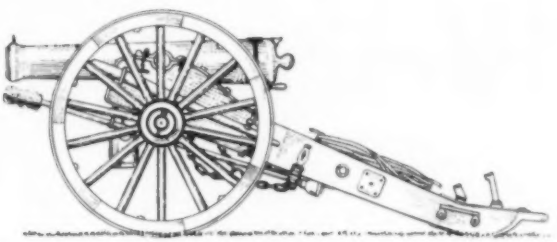
By Harold L. Peterson



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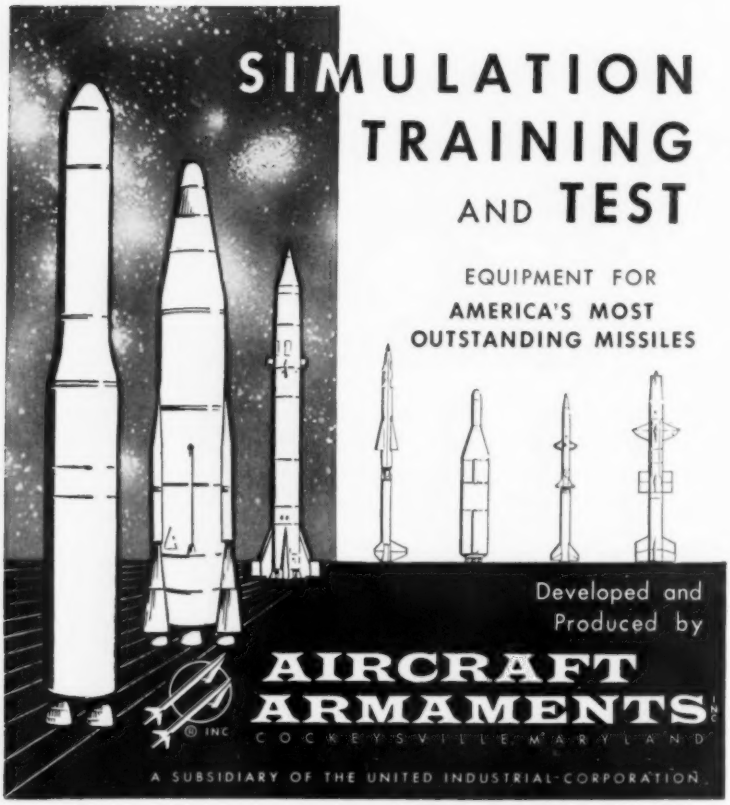

The A.O.A. Directory

The Annual Directory of the American Ordnance Association for 1959-1960 is available to members. This Directory is published in July of each year and has been mailed to the national and local officials of the Association, members of the Technical Divisions, and A.O.A. company members. Other members may receive a copy on request. The Directory lists the following:

- Members of the Association's Council
- National Board of Directors and Executive Committee
- National Officers and Advisory Board
- Officers and Directors of All Local Posts
- Members of the National Technical Divisions
- Honor Roll of A.O.A. Company Members
- Organization Chart of the National Association

The Directory shows the A.O.A. office held by each individual listed and also gives his company affiliation and location. It is available to Association members only. Address requests to:

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Rockets & Missiles (Contd.)

Crockett, has been mentioned. This anti-tank weapon is to be tipped with a sub-kiloton atomic warhead and would be able to destroy any tank. This weapon would be shoulder-fired, too, from a light launcher.

First launching of the Navy Tartar surface-to-air guided missile was made from the U.S.S. NORTON SOUND off the Pacific Coast. Tartar has a diameter of about twelve inches and is about fifteen feet long. A dual-thrust solid-propellant rocket engine supplies high thrust for launch and long-duration thrust for cruise. An advanced version of the Terrier, the Tartar will be used for antiaircraft defense on destroyers.

Propulsion.—Perhaps the biggest propulsion news lies in the recent Air Force and Navy cancellations of the boron fuels program. After spending about $200 million and several years in building two tonnage-producing plants, the program was called to a halt.

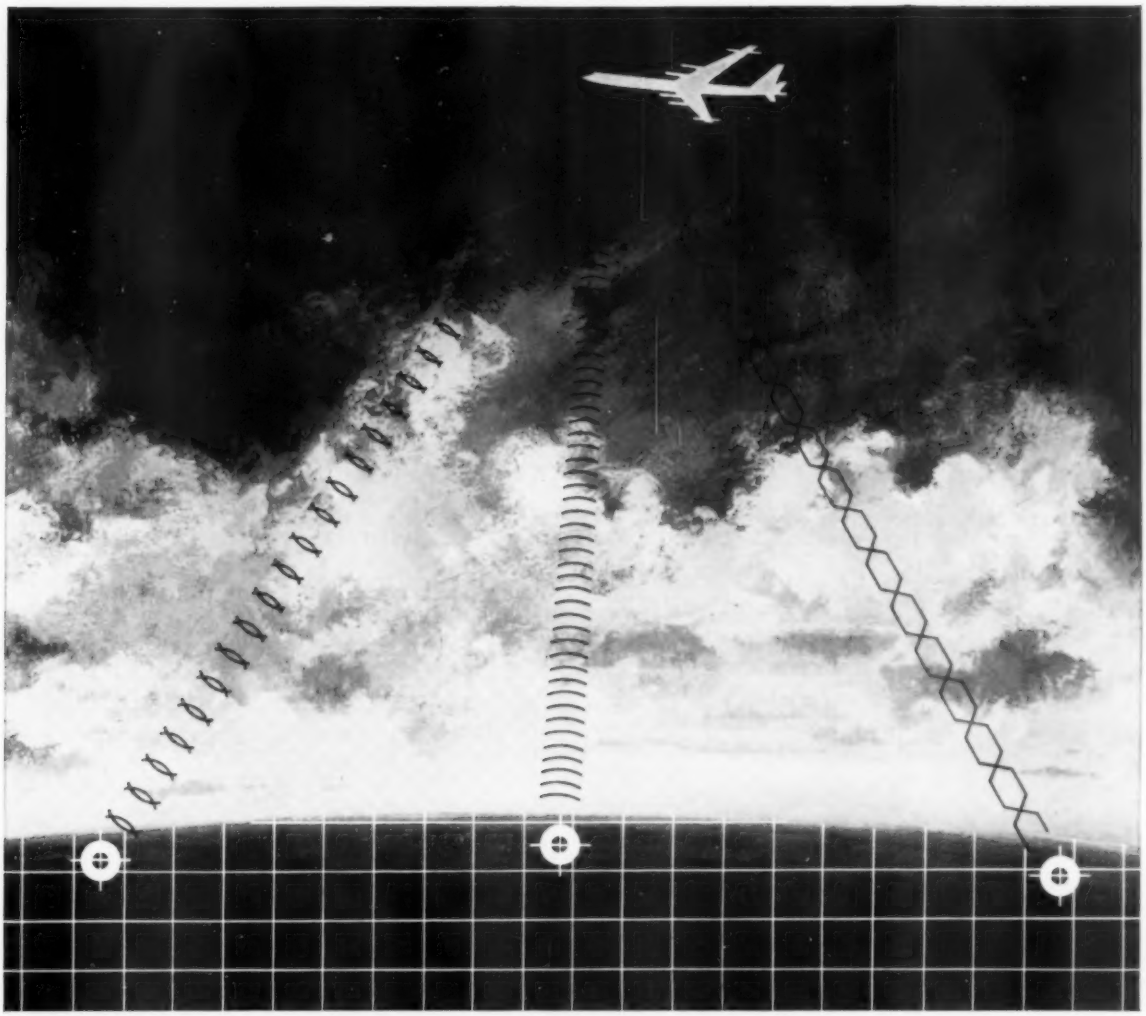
Reasons: the boron fuels gave a much lower performance than anticipated in turbojet engines, the cost was several dollars per gallon, and handling difficulties were encountered. The decision not to mass-produce the boron high-energy fuels, however, does not affect research and development. How the status of boron fuels will affect the rocket and ramjet programs is not known.

Several new developments in solid propellants have been announced. For example, Aerojet-General Corporation and Acoustica Associates, Inc., will jointly explore sonic control of solid motors. It has been found that high-frequency sound waves can affect the burning of solid rockets and that this may offer a method of control, such as throttling the thrust of solid rockets by varying the signal of a high-frequency transducer.

It finally has been revealed that aluminum additives to solid propellants are responsible for considerable increases in performance. Ultrafine aluminum powder (with diameters often in the micron range) is added to conventional fuel binders and ammonium perchlorate oxidizer combinations. The Polaris rocket is said to use this type of propellant.

The plug nozzle is being looked at as the solution of the multimillion-pound-thrust rocket engine. The plug, or nozzle wall, is a spike which protrudes from an annular ring from which the exhaust gases stream. Thus, combustion takes place in a ring around the base of the spike. Such nozzles are being studied by General Electric Company under an NASA contract. It is said that such plug nozzles are self-adjusting to altitude. Present nozzles are designed for optimum operation only at one altitude.

SYLVANIA ELECTRONIC SYSTEMS . . . **IN RECONNAISSANCE**



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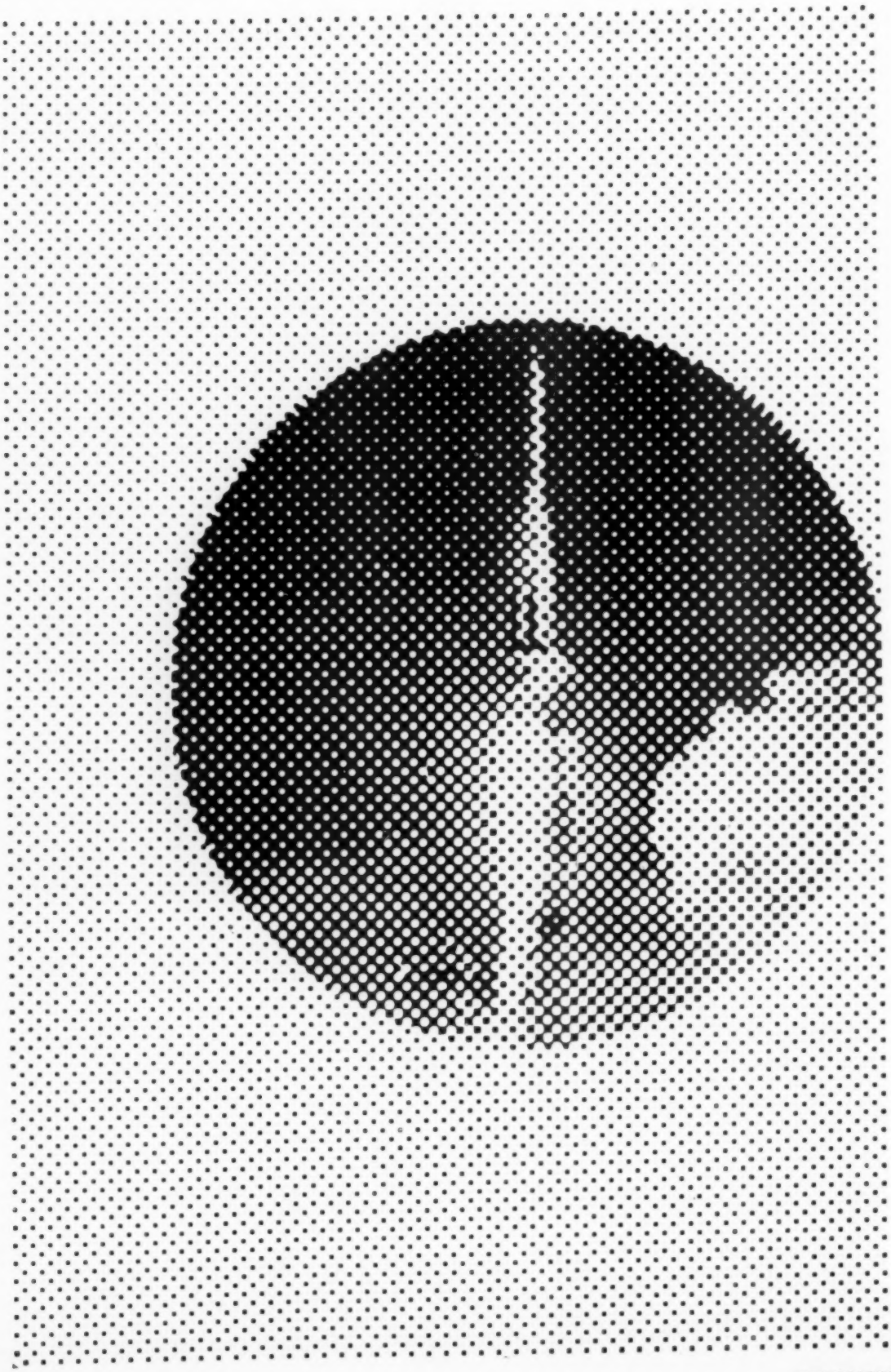

There are 7,500 dots shown here.
This is the number of engineers in the eight divisions of Martin. And 40 percent of these—the 3,000 dots in the circle—are electronics/electrical engineers.
It is this specialized capability that enables Martin to develop electronic systems which anticipate the exacting demands of the missile-space age.
Example: A Martin electronic system known as Master Operations Control (MOC) has been a vital factor in the exceptional performance of TITAN. By automatically checking the hundreds of systems necessary to successful flight, MOC has removed much of the human error from complicated countdown procedures.

The eight divisions of The Martin Company are Activation, Baltimore, Cocoa, Denver, Nuclear, Orlando, RIAS, and Space Flight.

ARMAMENT ELECTRONICS

W. H. Van Vliet

Polar-Orbit Tracking.—It has been revealed that ARPA's tracking and acquisition facilities at Vandenberg Air Force Base for surveillance of the polar-orbit satellite will be strengthened by the addition of another station located in the Midwest.

Heaterless Tubes.—Vacuum tubes which require no heater or filament power may be developed through the use of certain semiconductor crystals which can be made to emit electrons. Westinghouse scientists have discovered that a tiny silicon carbide crystal will emit electrons when a voltage is applied across a built-in junction with current density comparable to that of a small receiving-type tube. The use of semiconductor crystals in place of the heater and cathode would eliminate filament power supplies and the heat created by the hot filament.

Biax.—The Aeronutronic Division of Ford Motor Company has developed magnetic computer elements capable of high-speed operation up to 20 mc. a second in logical networks and memory arrays. The element, called "Biax," is a small rectangular bar of ferrite magnetic material. Two elements, a memory element and a logic device, were developed. These devices may replace semiconductor devices such as transistors and diodes. The Biax elements can be used in many types of military and commercial computing equipment.

Nuvistor.—A new form of vacuum tube, called a "Nuvistor," is under development by Radio Corporation of America. The company reports that the tube, far superior to conventional miniature electron tubes, can compete with transistors in many fields presently dominated by semi-

(Continued on p. 482)

Lieutenant Colonel Van Vliet, U.S.A.F. (Ret.), formerly director of armament electronics, Northeast Air Command, and formerly chief of the Operations Division, Air Force Ammunition Services, is an electronics systems engineer in the California Division, Lockheed Aircraft Corporation, Burbank, Calif.

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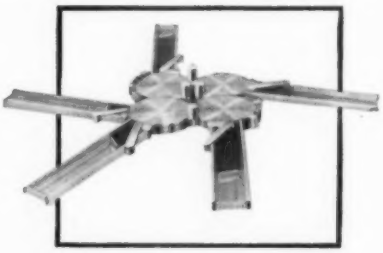

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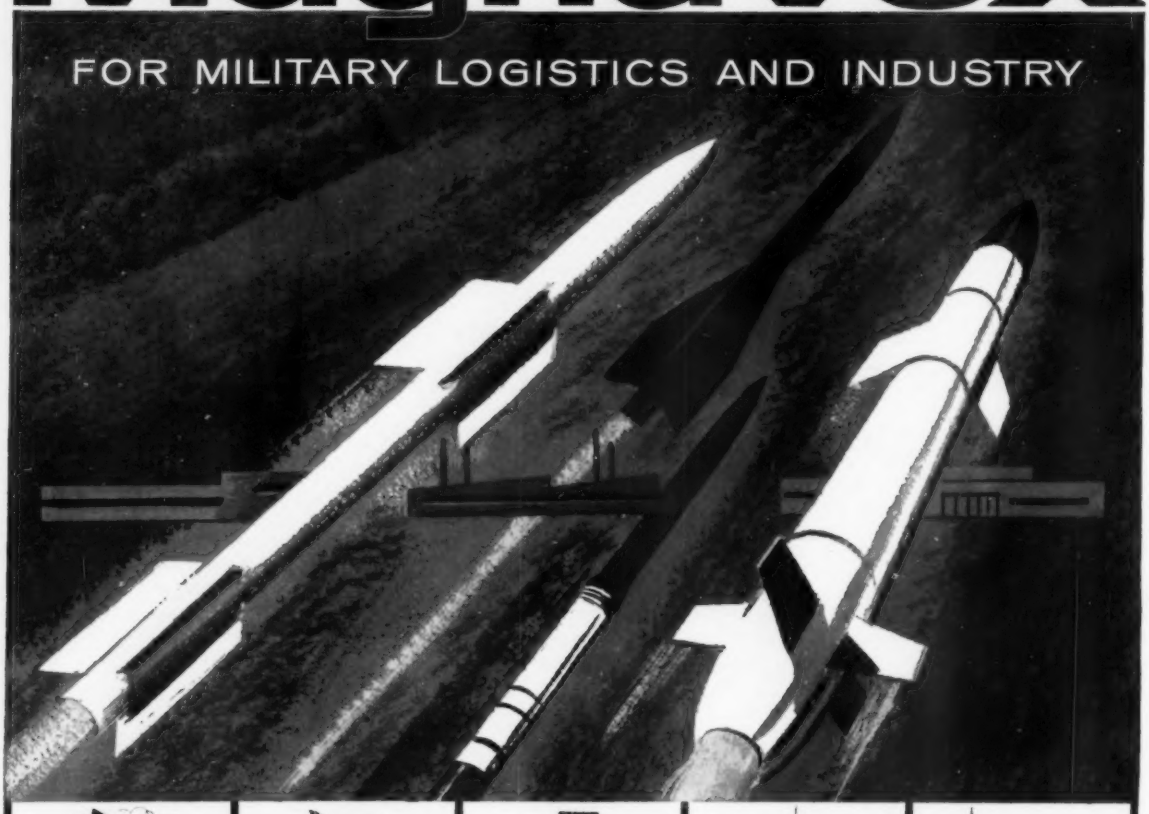

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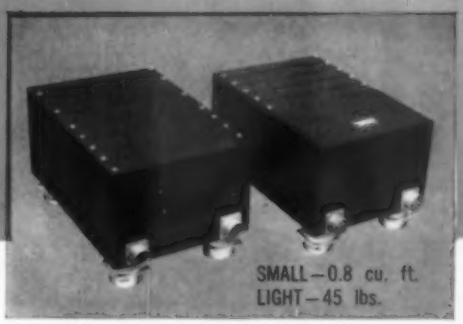

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conductor devices. The Nuvistor incorporates concentric elements, which will permit miniaturization to a point where it will compensate for the negligible heater power required. Also, due to the concentric construction, the tubes are capable of high plate dissipation.

Super Radar.—Cornell Aeronautical Laboratory, Inc., already successful in transmitting microwave pulses to a peak power of 21 million watts, has received an Army Ordnance contract for continued research. Present plans are for development of techniques and equipment capable of 50 million watts of peak radiated power at various pulse lengths and repetition rates, with an average power of 50,000 watts.

BMEWS Antenna.—An 84-foot-diameter radar antenna, designed for use with the Air Force's Ballistic Missile Early Warning System (BMEWS), has been developed by Goodyear Aircraft Company for Radio Corporation of America, prime contractor for BMEWS. The antenna is enclosed in a 140-foot-diameter rigid spherical radome. The antenna system is now being installed at RCA's Moorestown, N. J., facility for testing and evaluation purposes.

Atmospheric Density.—A new device for measuring atmospheric density and temperature has been developed by Lockheed Aircraft Corporation for use in satellite guidance systems. As the satellite moves through the atmosphere, an airstream rushing through an aperture is chopped by a series of whirling blades in the device.

The pulsing airstream strikes a microphone and produces a tone. The density of the atmosphere is determined from the intensity of the tone and the temperature is determined by measuring the length of the pulses.

Long-Haul Communications.—A single military long-haul communications network for all services has been planned and will be effected through integration and expansion of existing and separate service facilities. The network will not include specialized communications such as those required by SAC and ADC control systems or those forming integral parts of weapon control systems. The network will be developed during the next ten years on an evolutionary basis and will be under control of the Joint Chiefs of Staff.

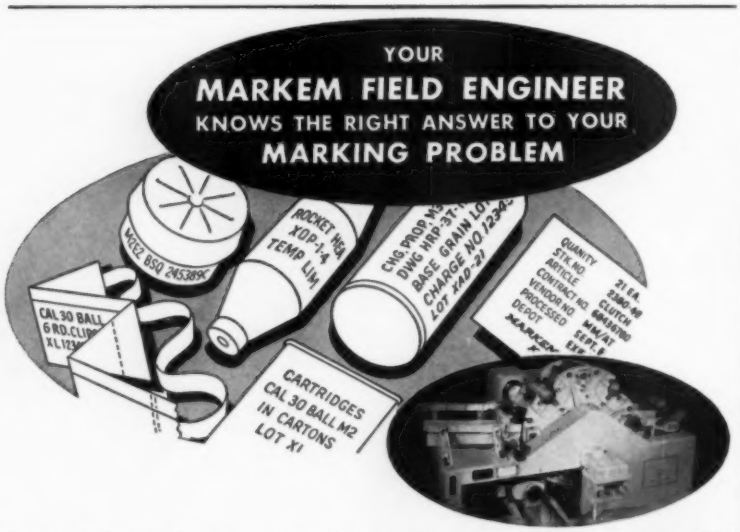
IFF.—A new radar recognition set, AN/APX-7, has been developed for the Navy by Packard Bell Electronics Corporation. The set, an integral part of the Mark X IFF system, is capable of a peak power of over 2 kw. at L-band frequencies. Full power can be obtained up to 35,000 feet, with power output automatically halved for altitudes between 35,000 and 50,000 feet. A high-mu, air-cooled 2C39A lighthouse triode and coaxial line cavities with plate pulse modulation are used in the high-level RF stages in the transmitter. The receiver incorporates a crystal-controlled oscillator and gain time control to reduce indicator noise by reduction of receiver gain for near-by responses.

High-Speed Checkout.—A new automatic checkout system, capable of up to 10,000 test decisions a second, has been developed by Epaco, Inc. The high-speed system incorporates digital computer switching and decision-making techniques, and is capable of completing preflight checkout in a matter of seconds or a complete trouble analysis in minutes whenever required.

An appreciable amount of a device's operational life is consumed in testing. For instance, one interceptor fire-control system receives a total of 700 hours of testing at the airframe manufacturer's plant and an extra 5 hours of ground testing before each flight. Therefore, speed-up of the checkout system could greatly increase its operational life by reducing test time.

One feature in the automatic checkout equipment is its ability to make dynamic performance measurements on servomechanisms and other devices where conventional static measurements do not satisfactorily determine actual circuit performance. A similar system is being developed for General Electric Company which will monitor an atomic reactor. Other systems developed, or under development, are for AC Spark Plug's Thor inertial guidance system, Convair's Terrier and Atlas missiles, and for Douglas Aircraft's Nike Zeus.

Missile Telemetry.—A telemetry system designed for use in missiles and space vehicles has been developed by Lockheed Aircraft Corporation. The pulse-amplitude, frequency-modulated (PM-FM) system incorporates a Lockheed multiplexer which is capable of combining 8 channels of information, each containing up to 5,000 bits a second, into a single channel transmitting up to a total of 40,000 bits a second. If desired, the original 8 channels can be divided into 64, 128, or 256 channels. At the ground receiving station a demultiplexer separates the data back into the original number of channels. It is possible to transmit four times as much information with this system as with present conventional systems.



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Coiled sheet, thin wall castings, many other production items are now available from Dow's big rolling mill, foundry and fabrication facilities.

Manufacturers on the alert for improved materials and production methods would enjoy a quick tour of the four Dow plants that turn out magnesium products. New ways of forming and fabricating magnesium now being practiced in these plants open up new areas of use for the lightweight metal.

TOOLING PLATE, extra flat, is annealed to eliminate residual stresses.

At the huge Madison, Illinois, rolling mill, for example, they're making magnesium sheet that doesn't require stress relief after welding. This is a major step forward in light metal technology and a boon to manufacturers using magnesium assemblies. Madison has also increased the maximum width of sheet to six feet. Five different sheet alloys, including elevated temperature alloys, are now available either flat or in coils.

To keep abreast of the rapidly increasing demand for precision jigs and fixtures, Madison keeps a close watch on the tolerances of Dow magnesium tooling plate. Typical flatness tolerances, for example, are 0.010 inches in any six feet. This means greater accuracy and less machining for users of Dow tooling plate. A mammoth 13,200 ton extrusion press, also located at Madison, is now turning out magnesium extrusions up to 30-inch circumscribed circle in size.

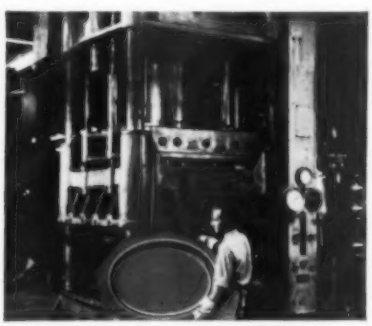
Over in Bay City, Michigan, interesting things are happening, too. At the well-equipped Dow magnesium foundry, largest in the U. S., sand and permanent mold castings of all sizes and shapes are being produced on a volume basis. Complete facilities are maintained for heat treatment, styrene DMI impregnation and chemical treatment. A well-staffed quality control team makes sure that all specifications are met or exceeded, and that the most modern equipment and techniques are fully utilized.

The Bay City foundry casts many complex and difficult designs. Large castings with walls as thin as 0.100 are now being produced. Other useful developments include cast-in tubeless passageways for use as hydraulic lines, special coring techniques for casting enclosed shapes and new magnesium casting alloys.

A new die casting plant is now on stream at Bay City. This facility houses the most advanced magnesium die casting equipment, including cold chamber metering units which automatically feed metal to the machines and contribute to unusually high production rates. To assure close alloy composition control in both die casting plant and foundry, a direct reading spectrometer provides frequent and precise analyses of the molten metal. Similarly, X-ray equipment is also available where radiography is needed in quality control.

The Dow fabrication plant, also in Bay City, offers capacity for volume work on magnesium assemblies. Here, too, developmental work on magnesium is constantly in progress. The plant is set up to handle large or small jobs, and plenty of both. Its activities include deep drawing, bending, spinning, stamping, piercing, machining, arc and spot welding, assembly, chemical treatment and painting. This plant has pioneered many "firsts" in magnesium production, such as hot drawing, spot welding and automatic welding.

DOW FOUNDRY offers production capacity for sand and permanent mold castings of all sizes.



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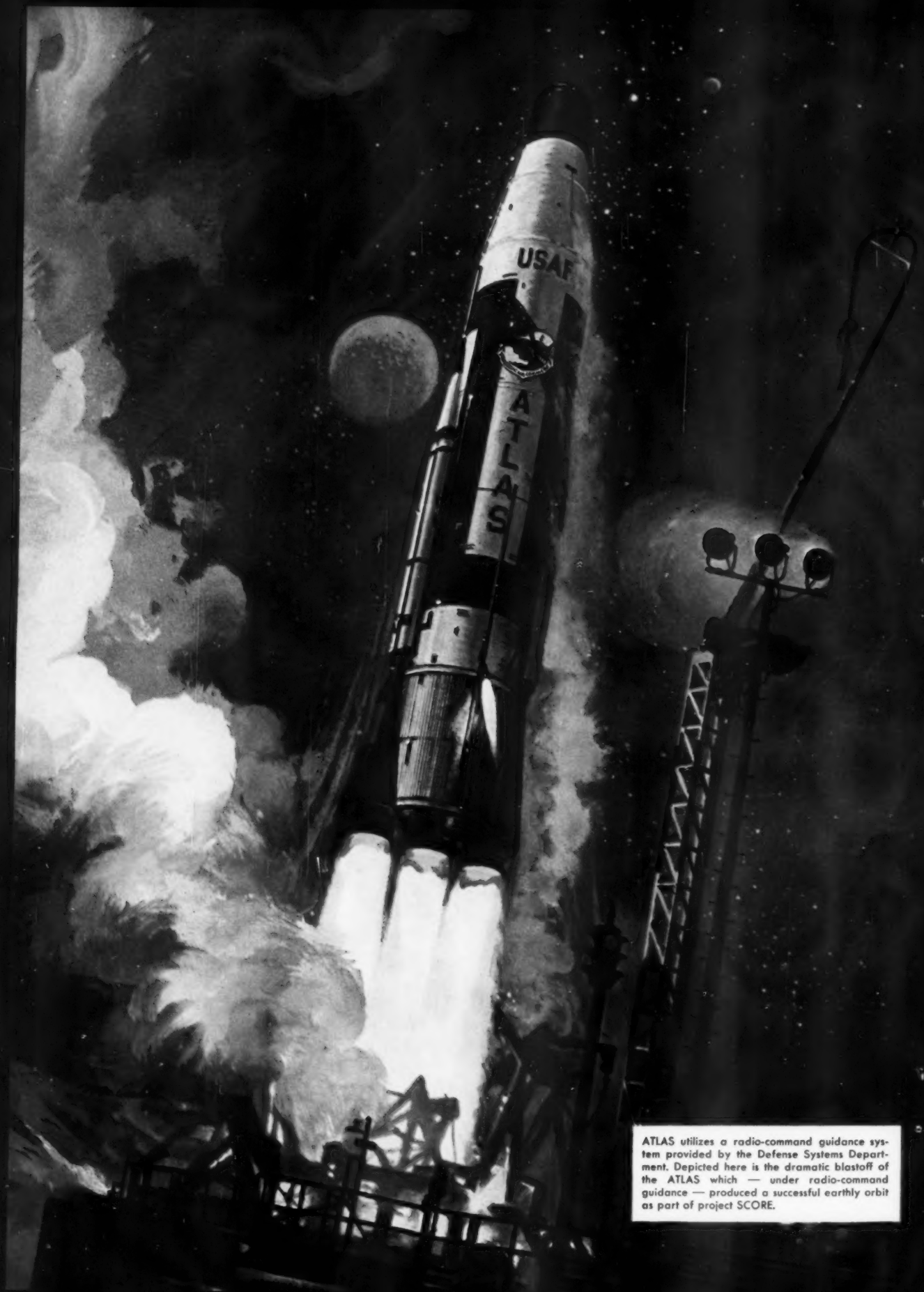

ATLAS utilizes a radio-command guidance system provided by the Defense Systems Department. Depicted here is the dramatic blastoff of the ATLAS which — under radio-command guidance — produced a successful earthly orbit as part of project SCORE.

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LIGHT MILITARY ELECTRONICS DEPARTMENT

SIDEWINDER

. . . the deadly air to air missile whose infrared guidance and control units are provided by the Light Military Electronics Department, Utica, N. Y., is representative of its capabilities for military electronic subsystems and equipments contained in, or launched from, air vehicles. Its additional contributions range from electronics countermeasures to integrated avionic systems.

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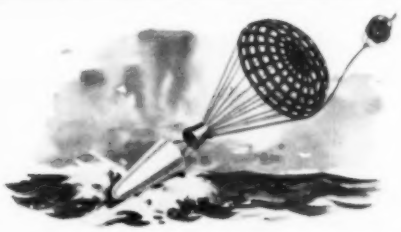

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. . . such as the ATLAS experimental nosecone — largest re-entry vehicle ever recovered from space — are designed and built by the Missile and Space Vehicle Department, Philadelphia, Penna. Experienced in space technology, MSVD developed operational ATLAS and THOR re-entry vehicles. Other responsibilities range from certain missile arming and fuzing projects to the re-entry/recovery vehicle of the DISCOVERER satellite. 226-3

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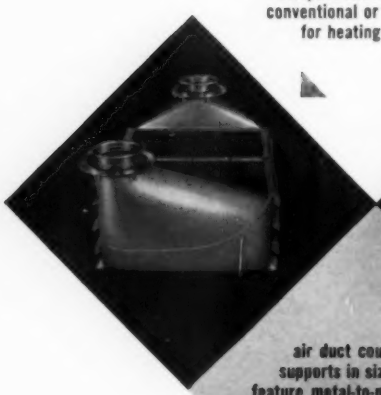

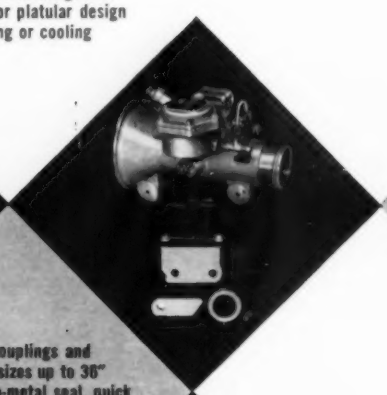

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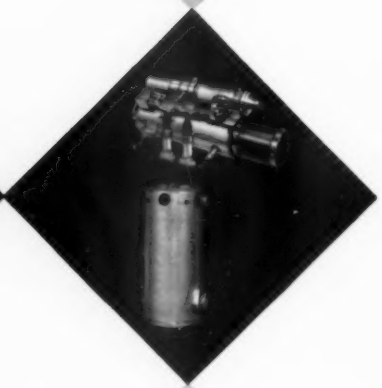

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The Missile Train—Mobile Sunday Punch

In the foreground above is the missile train—a hit-and-run Sunday punch for our modern Army. In event of war, the train could fire a missile with nuclear warhead, move rapidly miles away, then fire other missiles . . . without becoming a vulnerable stationary target itself. The missile train would be an ever-present threat to the enemy's tactical units over a wide area.

For such imaginative projects as the missile train, which combines maximum mobility with maximum firepower, ARMA has developed an equally imaginative universal navigation system. Not only can ARMA systems rapidly locate and aim all types of Army missiles, but they are applicable to all types of land, sea and air operations. To the Army, ARMA offers precise vehicular navigation systems for use in artillery and missile survey, combat vehicles, tanks, and helicopters as well as remote control types for mine detection and atomic blast survey. Precision navigation systems are ARMA's business from ships to ICBM's and--beyond.

ARMA, Garden City, N. Y., a division of American Bosch Arma Corp. . . . the future is our business.

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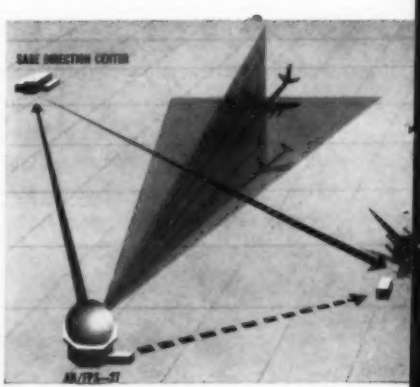
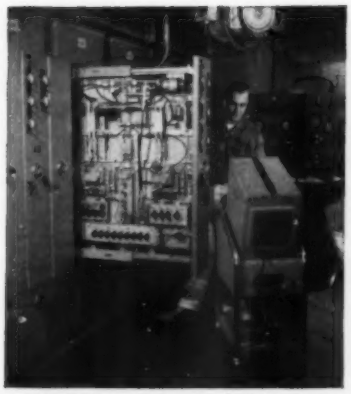
CAPABILITIES FOR DEFENSE

Westinghouse AN/FPS-27 Radar in operation at an Air Defense Command site

A single Westinghouse radar gets a 3-D fix on the enemy...dilutes his jamming ability

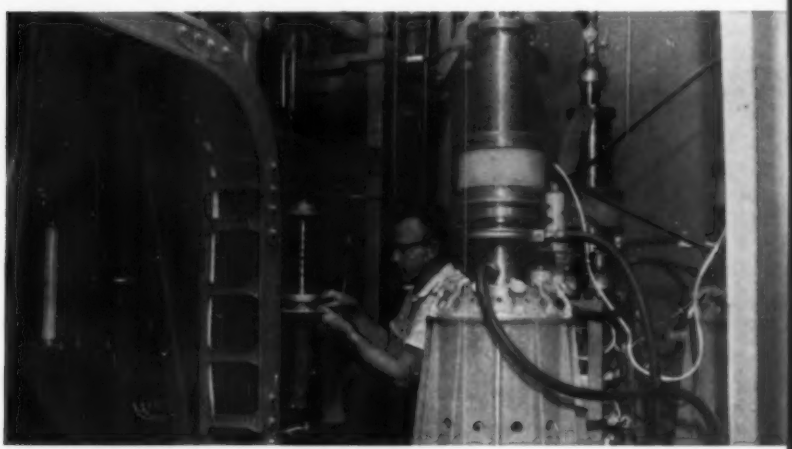
The AN/FPS-27, versatile 3-D radar designed by the Westinghouse Electronics Division for the Air Force's Rome Air Development Center, is achieving new standards of performance, reliability . . . and economy. Now under contract from the Rome Air Materiel Area, this high-power, stacked beam radar gathers range, azimuth and height data quickly and accurately while eliminating unwanted signals. These comprehensive functions in a single radar represent the application of the latest state of the art radar techniques to our nation's early warning defense.





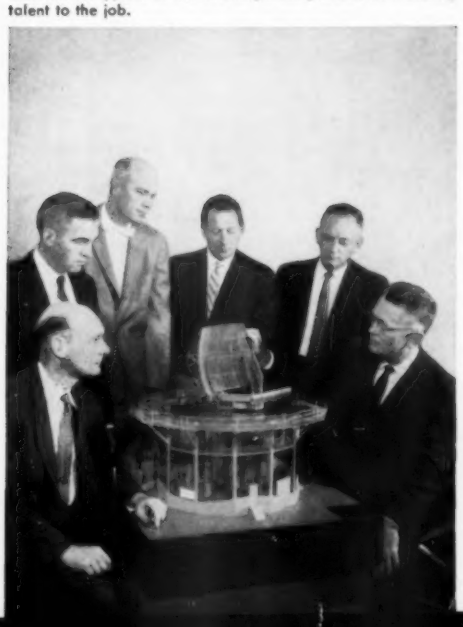
MAINTENANCE EASE: AN/FPS-27 design stresses reliability and maintenance accessibility. A separate monitor console calibrates the receivers remotely. Equipment troubles are automatically indicated. Sub-assemblies can be replaced rapidly in case of circuit malfunction.

UNIQUE CONSTRUCTION DESIGN of the antenna system permits the inclusion of the latest 3-D height-finding techniques. Range, azimuth and height data can be automatically fed to a computer to form a composite picture of the air defense sector.



EASE OF OPERATION: One man operates the entire transmitter room. This is typical of the operational ease of the Westinghouse designed AN/FPS-27. A minimum team of six specially trained men can handle the operation and maintenance of the entire facility.

Here is the management team responsible for the development of the AN/FPS-27—within budget and on schedule. This team is typical of the Westinghouse practice of matching talent to the job.



The AN/FPS-27 is a part of a broad Westinghouse effort in shipboard, tactical and airborne radar. Current simulation studies at the Air Arm Division, utilizing the latest digital computer facilities (at right), hold promise for new approaches to the problem of long-range detection and tracking of aircraft and ICBM's.

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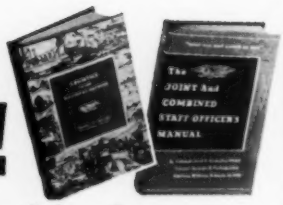

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Book REVIEWS

Reviews in this issue by:

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COL. GEORGE S. BRADY, *consulting engineer, author, editor, Washington, D. C.*

F. W. FOSTER GLEASON, *military historian, ordnance analyst, editor, Washington, D. C.*

MAJ. GEN. E. P. MECHLING, *aviation ordnance expert, editor, Washington, D. C.*

DR. JOHN J. O'CONNOR, *educator, author, editor, Washington, D. C.*

W. H. RUSSELL, *educator, historian, Annapolis, Md.*

COL. PHILIP SCHWARTZ, *author, ordnance expert, Pasadena, Calif.*

ORVILLE C. SHIREY, *major, Infantry, U. S. Army Reserve, Washington, D. C.*

LIEUT. COL. S. M. SMOLENSKY, *engineer, Andover, Mass.*

COL. HENRY C. THAYER, *ordnance management engineer, logistician, Washington, D. C.*

Sylvanus Thayer of West Point. By George Fielding Eliot. New York: Julian Messner, Inc. 192 pp. $2.95.

GEORGE Fielding Eliot has performed remarkable service to our country in writing "Sylvanus Thayer of West Point" at this time. In the portrayal of Thayer and his period, the author has brought into fresh focus our continuing need for completely loyal, fully educated leaders for our military establishment. He stresses the importance of intensive application in adequate studies and the proper place of firm discipline in the education of young men. This is also of current interest.

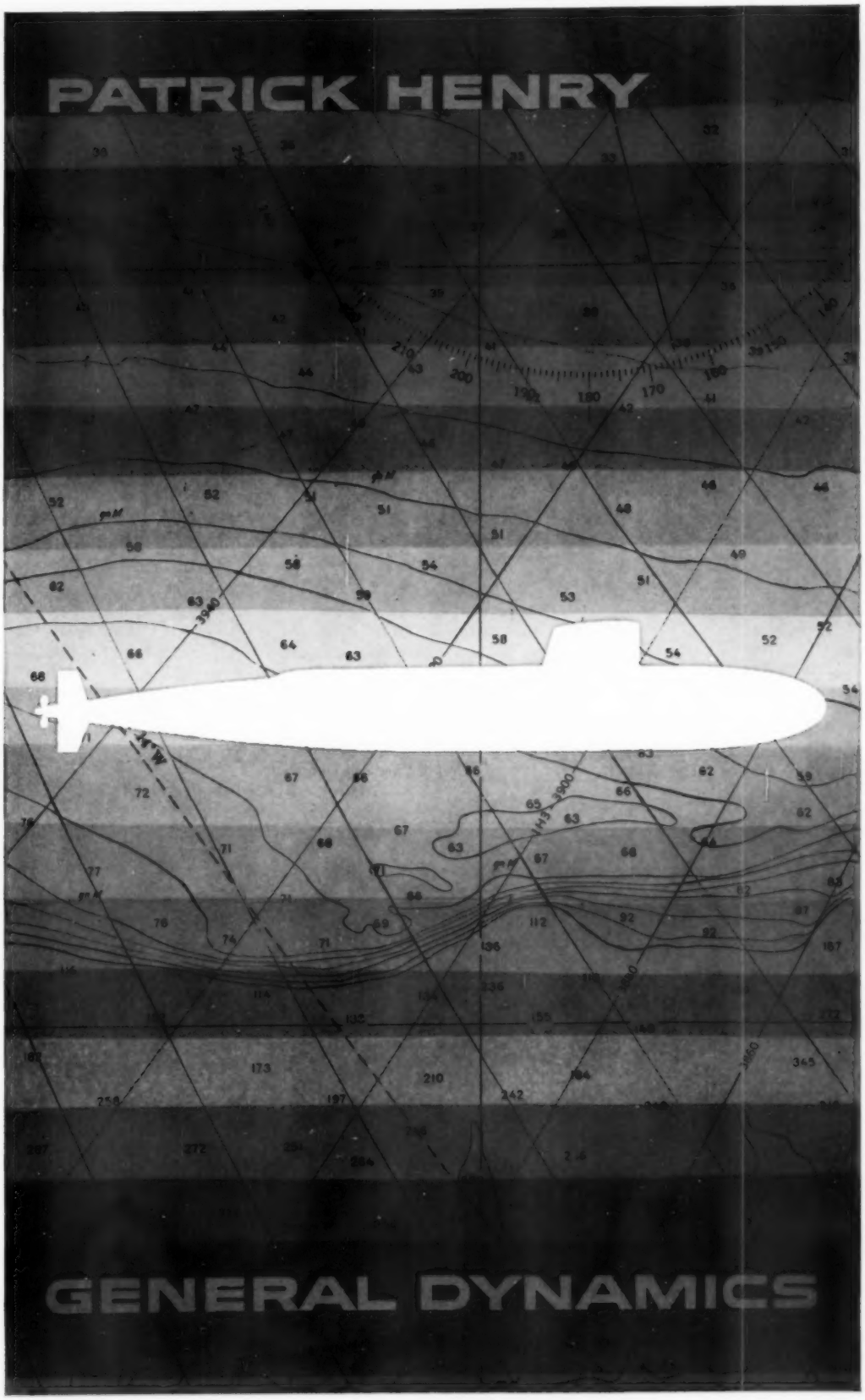
One of the things which makes this book memorable is the author's firm understanding of Sylvanus Thayer and the way in which he influenced West Point and the life of his time.

Most men, even notable men, must be content with affecting decisions only in their own times. This book clearly shows that Thayer's is still the dominant influence at West Point. His influence on other technical schools remains great, if not so easily identified. I am sure that General Thayer would be pleased to know that his ideas, and particularly his teaching plan, will be perpetuated at the new Air Force Academy as well as at West Point.

George Fielding Eliot has here effectively epitomized the true importance of Sylvanus Thayer and his triangular concept of the purpose of West Point with honor as the foundation from which education and discipline arise, converging toward the end product—the kind of military leadership our country still looks to for survival.—EDWARD P. MECHLING.

Command Decisions. Edited by Kent Roberts Greenfield. New York: Harcourt Brace and Company. 481 pp. $5.95.

THIS collection of twenty challenging essays was prepared by distinguished historians in the Office of the Chief of Military History, Department of the Army, for study by the Army's



Launched September 1959, the ballistic-missile-firing Patrick Henry SSB(N)599 is the seventh nuclear-powered submarine designed and built by General Dynamics Electric Boat Division.

Command and General Staff School. When the project was completed, it seemed appropriate that the book should be made available to citizens everywhere. It is, consequently, the only volume of the Army's elaborate history series to receive commercial publication.

In his pithy introduction, Hanson W. Baldwin makes the point that American military victory in World War II did not win a political peace and that future generations should ponder the lesson of experience; namely, that war, if it is to have any meaning, must have a compound military-political objective.

It would seem that some of our World War II decisions were military, some were military-political. But whatever their nature, they were not fitted into a general military-political objective. This is the burden of Mr. Baldwin's complaint, and it is certainly worthy of the most serious consideration.

The twenty decisions here subjected to dispassionate and documented analysis range all the way from the basic concept of Allied strategy in World War II to the decision to use the atomic bomb. Of special interest are the Japanese decision for war in 1941, Hitler's decision to invade Norway and Denmark, and the German counteroffensive in the Ardennes. The volume represents the best available American evaluation of some of the successful, blundering, and questionable command decisions of the greatest war in history.—JOHN J. O'CONNOR.

Thirteen Days That Shook the Kremlin—Imry Nagy and the Hungarian Revolution. By Tibor Meray. New York: Frederick A. Praeger, Inc. 290 pp. $5.

WHEN the Hungarian revolution was in progress the American public was deluged with newspaper accounts that pictured the revolutionists as "freedom fighters" for democracy. The author of this book, an outstanding Hungarian journalist, shows clearly that, although the majority of the people did not want Communism and thousands took the opportunity to escape from it, the revolution itself was not a democratic revolt but merely a Tito-type uprising against the foreign domination of the Russians. Had the revolution won, Hungary would have remained a Communist country.

Even if Nagy had been a stronger character it is still doubtful if Hungary could have broken free of Russian rule because it did not enjoy the geographical isolation that Yugoslavia had. That no help came from the West was a cause of disappointment and despair to the enslaved peoples who had mistaken newspaper and radio bombast for real promises.

One thing stands out clearly. Nagy as a leader was an idealist who believed that he could treat with the Russians. He found that not even the official signature of a Soviet representative could be trusted, and he paid with his life. Those Americans who still cling to the belief that we can do business with the Russian Soviet system will do well to read this book.—GEORGE S. BRADY.

Gun Digest. Fourteenth annual edition. Edited by John T. Amber. Chicago: Gun Digest Company. 320 pp. $2.95.

THIS large and handsome annual is of consuming interest each year; but this reviewer has found that the greatest reward comes with adding to a growing series. Nine volumes now grace his bookshelves, and, in addition to answering innumerable questions and providing a smooth-flowing record of trends in firearms and their use, they offer many an hour of rereading.

This year, as in every year, the diversity of coverage in Gun Digest is truly amazing. Several years ago Amber began to include significant historical coverage of ordnance items; this trend continues and is stepped up. The lead editorial is a reprint from ORDNANCE; Jac Weller furnishes a thought-provoking article on the trend in military rifles; Mel Johnson contributes a study of "fumbling" in the development of the machine gun. It all adds up to an ordnanceman's delight!

Over fifty articles and departments run the gamut of firearms, hunting, collecting, target and practical shooting, miniatures, and engraving. Illustrations are profuse and excellent.—F. W. FOSTER GLEASON.

Jet Propulsion Engines. Edited by O. E. Lancaster. Princeton: Princeton University Press. 799 pp. $20.

THIS book is the twelfth in the series entitled "High-Speed Aerodynamics and Jet Propulsion." Upholding the high quality of presentation embodied in the past volumes of the series, "Jet Propulsion Engines" contains detailed discussions of the many forms of jet propulsion available. Liberal use has been made of analytical material and the basic ideas treated in previous volumes of the series.

The book is divided into twelve major sections starting with the history, definitions of basic parameters, and a performance analysis of turbojets which is based on the internal solution of matching the compressor, combustor, turbine, and exhaust nozzle. Off-design performance is included.

Other sections analyze the turboprop, ramjet, and wave engines. Liquid-propellant rockets are considered primarily from the propellant aspect—both monopropellants and bipropellants. The portion on solid-propellant engines stresses stability and burning characteristics. Possibilities of using hybrid engines, such as the ram rocket and jet rotor, are considered.

"Jet Propulsion Engines," is a most valuable addition to the technical literature and is firmly recommended to anyone engaged in the study and application of reaction-type engines.—LOREN E. BOLLINGER.

The Great War: 1914-1918. By Cyril Falls. New York: G. P. Putnam's Sons. 447 pp. $5.95.

IN these days of the cold war with easily accessible panic buttons and with the Korean conflict and World War II serving as effective roadblocks to memories of earlier wars (except for the actual participants), it is well to be reminded that the preceding generation fought a tremendous war only four decades ago.

"The Great War" is such a useful summary of what we now call World War I. Captain Falls has written a readable book that covers, year by year, the concurrent "wars" that were conducted on the Western Front, the Eastern Front, Italy, the Balkans, the Middle East, Africa, and on the high seas.

Although the author states, "this is not a political history," he does manage to touch briefly on major political events as well as discussing the national leaders, military and civilian.

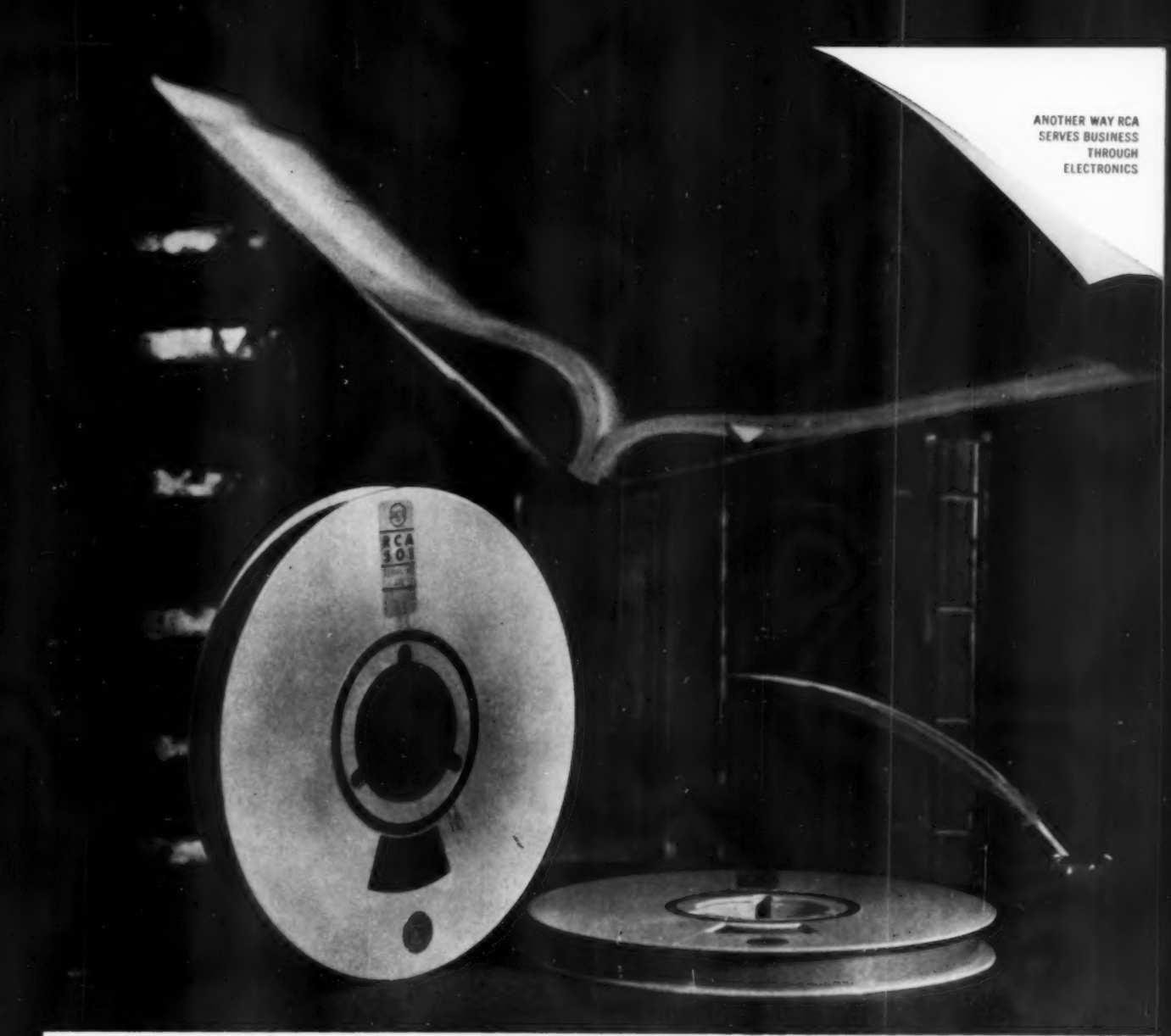
There is a keen appreciation of the governing effect of logistics on the decisions made on the far-flung battle fronts. The frailty of electrical communications, the general dependence upon horses instead of motors, the need for coaling ships—all such factors as well as the more obvious mud and mountain terrain conditions on the fixed or fluid fronts are noted and assessed for their influence in formulating battle plans.

In summary, "The Great War" is a highly readable brief history that is useful in reviewing again the cataclysmic years of 1914 to 1918 as seen through experienced British eyes.—H. C. THAYER.

The Failure of Atomic Strategy. By Col. F. O. Miksche. New York: Frederick A. Praeger, Inc. 224 pp. $4.50.

THE author, formerly of the Free French Forces of World War II and subsequently on General Eisenhower's staff, has been described as "one of the world's most stimulating military writers." Indeed he is!

His plea is for the West to rid itself of "Sputnik diplomacy" and support the aim of the defense of Christian civilization with an alliance based on solidarity and integration of all members on all questions, whether interests inside or outside



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To solve the problem, RCA drew on its broad experience in building computers for military applications and combed its many laboratories for the latest electronic advances that could help. The result was the RCA "501" high-speed electronic data processing system—the most compact, flexible, and economical ever built. It is a pioneer system with all-transistor construction for business use.

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Texas Instruments roof prism—viewer for photographic system used in the Douglas A3D-2P—helped photo map the landing flight path for North American's X-15

ROAD MAPPER FOR THE X-15

Texas Instruments roof prisms share a vital role in mapping a safe landing course for the first manned space craft. Installed in a photographic system aboard a Douglas A3D-2P, these prisms recorded landmarks that will guide the X-15 pilot in his return to earth. Accurate photo mapping at 600 miles per hour requires exceptionally high quality optical components. This roof prism, for example, has angles that must be held within seconds of arc. Difficult to manufacture? Not for TI craftsmen... tolerances such as these are met everyday at TI in production quantities.

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Book Reviews (Contd.)

of Europe are affected. This could be done with adequate quantities of conventional weapons to bolster our atomic deterrent and thus put the West in a negotiating position rather than being exposed to one blackmailing action after another until, perhaps, the final capitulation.—S. M. SMOLENSKY.

The Narrow Seas. By Reginald Hargreaves. London: Sidgwick & Jackson, Ltd. 495 pp. $6.30.

EVERYBODY knows that vigorous use of sea power made Britain great, but few recall the centuries of trial and error that so slowly taught Britons how much their survival depended upon controlling the English Channel. Reginald Hargreaves tells that story delightfully in the kind of book one likes to give friends at Christmas.

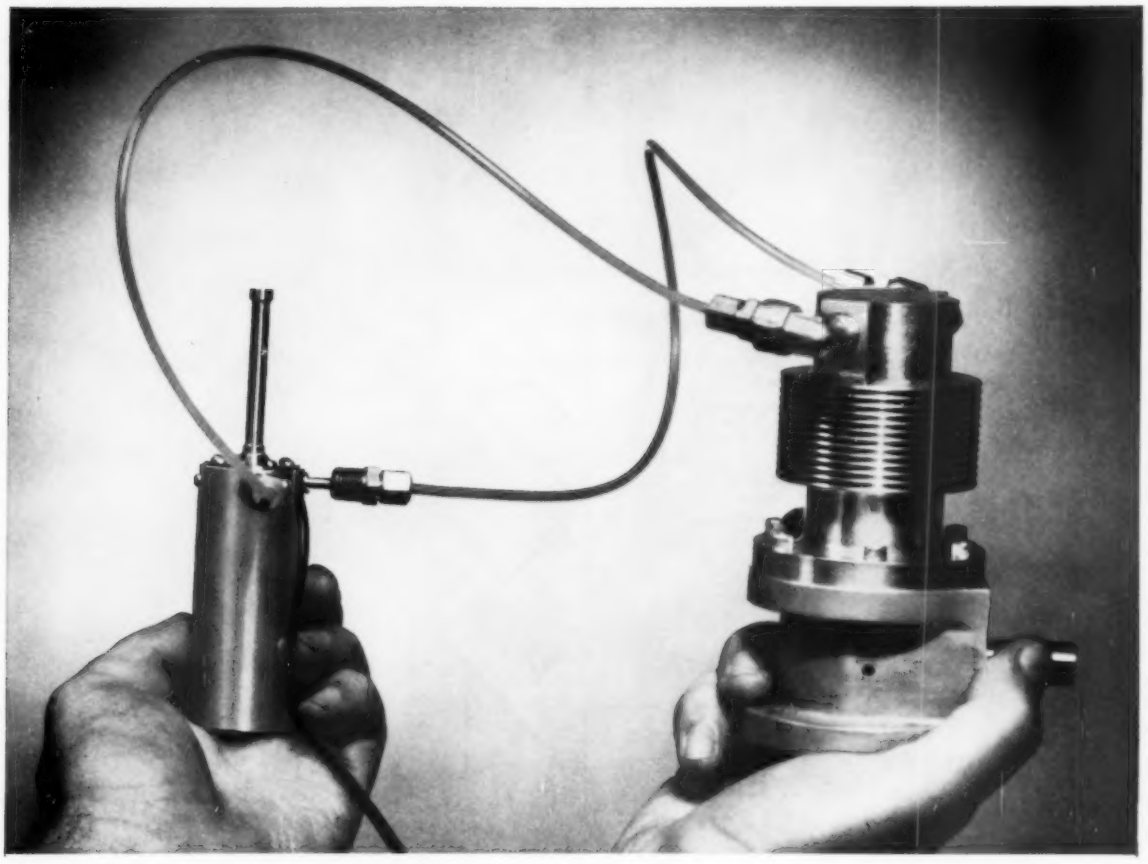
Drawing on forty years of historical writing, Major Hargreaves offers a tale suited to casual reading in short snatches or to careful study. He sketches economic and political forces underlying twenty centuries of struggle, frequently as stormy as the Channel herself, and against that background describes men or events as they appeared to their own contemporaries, thereby sustaining the impression that "you were there."

American readers of "The Narrow Seas" will discover that we are not the first impatient generation to call new weapons too costly, and they can compute the heavy tribute seventy British generations have paid to this age-old fallacy. Gradually the honest American will perceive that Hargreaves deals here with our history also, for ever since technology narrowed the Atlantic we, too, have been a people whose inner frontier is the European coast.—W. H. RUSSELL.

Battle—The Story of the Bulge. By John Toland. New York: Random House. 400 pp. $5.

IN this book the author reconstructs the Battle of the Bulge—the 1944 German counteroffensive through the Ardennes—using the "you-are-there" technique which seems to be gaining ground in historical and quasihistorical writing.

Mr. Toland has done a remarkably good job with his material, accumulated by a massive, personal-interview program over a 2-year period and by reference to most of the standard published sources. By skillful selection and editing of his interviews with American, German, and civilian participants he has been able to present a coherent historical account of the Battle of the Bulge in a series of vignettes. These make use of quotes of remembered conversations and give to the whole account a dramatic sense of immediacy and to the reader a sense of participation.—ORVILLE C. SHIREY.



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The min-IR-cooler was conceived by Arthur D. Little, Inc., and jointly developed with Hamilton Standard to perform with a Hamilton Standard-developed compressor offering high performance at unusually low weight. The system is an important new addition to the complete range of temperature and environmental control devices and systems produced by Hamilton Standard.

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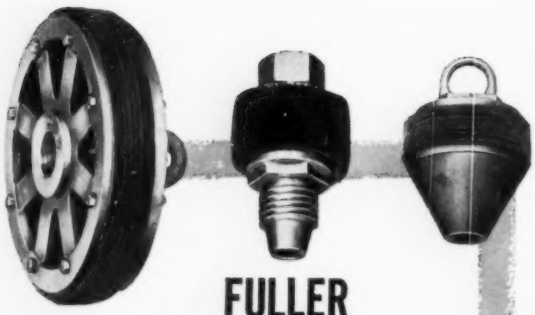

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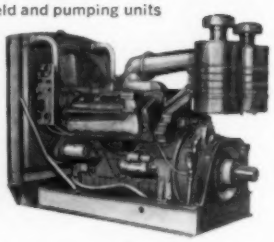

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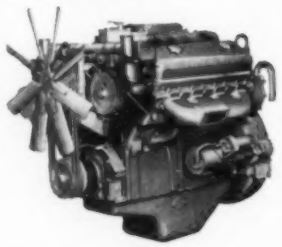

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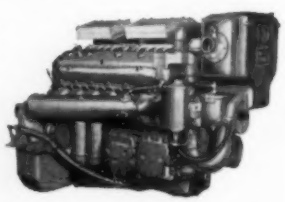

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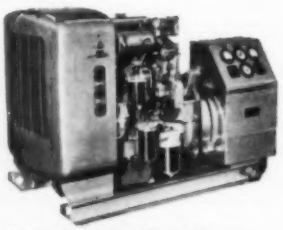

SPECIFICATIONS

Models	2-53	3-53	4-53	6V-53	2-71	3-71	4-71	6-71	6V-71	8V-71	12V-71	16V-71	Twin 4-71	Twin 6-71	Quad 6-71	Twin 12V-71	6-110†	Twin 6-110†
Bore & Stroke (in.)	3⅞ x 4½				4¼ x 5												5 x 5.6	
MAX. BASIC* HP @ RPM	47 @ 2000	97 @ 2800	130 @ 2800	195 @ 2800	67 @ 2000	118 @ 2300	167 @ 2300	252 @ 2300	252 @ 2300	336 @ 2300	504 @ 2300	675 @ 2300	334 @ 2300	504 @ 2300	1008 @ 2300	1008 @ 2300	335 @ 2000	670 @ 2000
POWER UNITS Net** BHP @ RPM	42 @ 2000	81 @ 2500	112 @ 2500	— —	60 @ 2000	90 @ 2100	131 @ 2100	200 @ 2100	198 @ 2100	256 @ 2100	387 @ 2100	527 @ 2100	256 @ 2100	392 @ 2100	780 @ 2100	794 @ 2100	274 @ 2000	541 @ 2000
FAN-TO-FLYWHEEL Net** BHP @ RPM	42 @ 2000	81 @ 2500	112 @ 2500	171 @ 2500	56 @ 2000	99 @ 2100	138 @ 2100	207 @ 2100	198 @ 2100	263 @ 2100	396 @ 2100	— —	— —	— —	— —	— —	274 @ 2000	— —
MARINE MAX. Net** SHP @ RPM	— —	86 @ 2800	120 @ 2800	— —	— —	110 @ 2300	151 @ 2300	235 @ 2300	230 @ 2300	308 @ 2300	456 @ 2300	607 @ 2300	— —	470 @ 2300	893 @ 2100	— —	314 @ 2000	628 @ 2000
Net** Cont. SHP @ RPM	— —	62 @ 2200	85 @ 2200	— —	— —	68 @ 1800	95 @ 1800	147 @ 1800	170 @ 1800	228 @ 1800	335 @ 1800	445 @ 1800	— —	295 @ 1800	590 @ 1800	— —	227 @ 1800	454 @ 1800
GENERATOR SETS KW Range**	13.5 to 24	— —	— —	— —	20 to 35	30 to 55	40 to 80	60 to 125	— —	— —	— —	— —	— —	200 to 245	— —	— —	100 to 170	— —

*60°F. and Sea Level **90°F. and 1500 ft. †4 Valve head

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Armament Technology

This section of ORDNANCE contains selected papers on armament technology presented at meetings of Technical Divisions and Sections of the American Ordnance Association and contemporary articles on armament research, development, manufacture, and field use

Cermets for Ordnance

Ceramic-metal mixtures meet the needs of high-temperature conditions

John M. Woulbroun
Metallurgist, Rodman Laboratory, Watertown Arsenal, Watertown, Mass.

HIGH-TEMPERATURE materials of pure metals and alloys experience an unfavorable degradation of properties at elevated-temperature service—they soften and become plastic. As a result, much research effort has been devoted in an attempt to restrain this undesirable feature by the dispersion of a hard phase of metal or ceramic within the ductile metal matrix. These compositions of pure metals, alloys, hard metals, and ceramics are now recognized as cermets.

The basic idea is not a new one as cermet systems have been widely used in the form of abrasive grinding wheels during the past hundred years. Cutting tools, metalworking dies, and ammunition cores made of combinations of tungsten and titanium carbide bonded with cobalt or nickel have been manufactured on an industrial basis for the past thirty years. The fabrication of these unique systems has been accomplished by powder metallurgy techniques.

THE current literature suggests that usable cermets for high-temperature application should consist of carbides or oxides bonded with metals and alloys of Co, Ni, Fe, Al, Cr, and Mo. It has been shown that cermets combine certain favorable properties of the components which are essential to successful application at elevated-temperature service. These favorable properties include strength, corrosion resistance, oxidation resistance, thermal conductivity, and thermal shock resistance.

The prerequisite of a potentially successful cermet system is strength at room temperature and at elevated temperatures. High strengths can be realized if wetting and good bonding occur between the hard brittle phase and the ductile metallic phase. L. S. Williams and P. Murray studied the wetting characteristics of various oxides and carbides by liquid metals. They found that carbides are more readily wetted by liquid metals than are the oxide systems due to the differences in the surface nature of the two classes.

THE carbide surface is dominated by the positive metal ions and the oxide surface by negative ions. Because of high surface energies, the carbides exhibit low interfacial tension with the liquid metals resulting in good wetting properties. It was concluded from their work that the free energy of formation of the oxide should not differ too much from that of the binder metal oxide since large differences in the free energies of formation promote undesirable chemical reactions which affect the physical properties by introducing new phases into the system—some of these phases being detrimental to sound structure.

CONTENTS

ARMAMENT TECHNOLOGY SECTION

Cermets for Ordnance 501
John M. Woulbroun
High-temperature resistant mixtures

Explosives Crystallization 506
Dr. Walter C. McCrone
HE production development

Jewel Bearing Dilemma 508
Robert Schwebel
Problem of increased demand

Weather to Order 512
F. Hermann and S. Sternbach
Frankford's climatic facility

% Vol.	Al_2O_3				TiC			
25	Fe	Al	Co	Co–Cr	Ni	Co	Fe	Co–Cr
50	Fe	Al	Co	Co–Cr	Ni	Co	Fe	Co–Cr
75	Fe	Al	Co	Co–Cr	Ni	Co	Fe	Co–Cr

Table I. Range by volume of cermet compositions in metallic binder.

A systematic research effort has been accomplished in the field of metal-ceramic interactions by W. D. Kingery and his colleagues. These investigations included the study of chemical reactions at temperatures up to 1,800 degrees centigrade. They found little or no reactions at 1,400 degrees centigrade and lower temperatures; however, considerable reactions took place in many systems at 1,800 degrees centigrade. The possible reactions which can take place include the formation of a new phase, penetration along the grain boundaries with the alteration of the oxide phase, and corrosion of the oxide phase.

The existence of these chemical reactions would therefore alter the physical properties of the cermet system undergoing temperature changes in the range 1,400 to 1,800 degrees centigrade. This postulates that an ideal system would be one where new phases are not formed, penetration is not observed, and corrosion of the oxide phase nonexistent. Fabrication methods become very important in order to achieve the final goal—a continuous binder phase surrounding finely dispersed particles of oxides or carbides, an achievement well illustrated by the WC-Co system.

Accordingly, a preliminary study of several systems was undertaken. Al_2O_3 and TiC were bonded with Fe, Co, Ni, Al, and Co-Cr in order to extend the knowledge of these systems over a wide range of compositions.

Certain considerations are necessary in the choice of materials. TiC and Al_2O_3 are two of the most successful hard-metal phases in various cermet systems because they are wetted readily by some of the ductile metals. These dispersions are readily available and low in cost. In addition, they are also acceptable in view of strategic considerations. The same reasoning holds true for the choice of the metallic binders.

The Al and Co are known to combine favorably with Al_2O_3, and Fe, Ni, and Co with TiC. These materials were chosen with the hopes of realizing good room-temperature properties and establishing sound criteria for material service at elevated-temperature service.

The cermets combining Al_2O_3 with Al, Co, Fe, and Co-Cr; TiC with Ni, Co, Fe, and Co-Cr; TiC with Ni, Co, Fe, and Co-Cr were prepared by powder-metallurgy techniques. The cermet compositions ranged from 25 per cent to 75 per cent by volume in metallic binder according to Table I. All compositions were lubricated with the addition of one per cent stearic acid by weight and ball-milled in glass jars for four hours. Original particle size was maintained by the use of small steel balls. Grinding of the metal and ceramic powders was not attempted at this experimental stage. Existing punch-and-die sets had to be corrected before the abrasive powders could be compacted. The pressures were then standardized at 30,000 psi.

An experimental sample of all compositions was treated at 275 degrees centigrade for half an hour in order to volatilize the stearic acid lubricant present in the mixtures. Three specimens for each composition were subsequently fired in a hydrogen atmosphere at 1,350 degrees centigrade for a period of two hours. Following preliminary determination of room-temperature transverse rupture strengths, new batches of all compositions were remixed. Lubrication, mixing, and pressing operations were performed according to the standards used for the experimental samples.

THE specimens were again treated at 275 degrees centigrade for half an hour and sintered for 2 hours at 1,250, 1,300, and 1,400 degrees centigrade (see Table III). The cermets were subjected to the hydrogen atmosphere during all sintering operations. The theoretical, apparent, and relative densities of the sintered cermet compositions were determined by standard procedures. The room-temperature transverse rupture strength tests were performed by the single-point loading method using a 0.75-inch span.

Specimens representing each cermet composition were subjected to metallographic examination. Photomicrographs were taken at three different magnification levels, these being 200 diameters for porosity studies, 500 and 1,500 diameters for the determination of microstructure and the degree of dispersion.

The results of the tests and metallographic examination varied widely for each system. Each system is therefore treated on a separate basis according to composition, density, microstructure, and strength.

The cermet systems composed of TiC-Co, Al_2O_3-Co, Al_2O_3-Fe (carbonyl), TiC-Fe (electrolytic), and TiC-Ni exhibited the most promising properties in decreasing order. The relative densities which were determined are exceptionally high in the case of the 25 per cent TiC, 75 per cent Co, system while densities of some of the other systems were considered to be below standard (see Table II). The systems Al_2O_3-Co, Al_2O_3-Fe, TiC-Fe, TiC-Ni had relative densities ranging from

Composition	% Rel. Density	Composition	% Rel. Density
Al_2O_3–25% Co	—	Al_2O_3–25% Fe	73.8
50% Co	67.9	50% Fe	74.5
75% Co	86.1	75% Fe	85.7
Al_2O_3–25% Fe	73.4	Al_2O_3–25% Fe	76.1
50% Fe	73.3	50% Fe	77.4
75% Fe	74.3	75% Fe	80.1
Al_2O_3–25% Al	69.8	Al_2O_3–25% Co–Cr	70.4
50% Al	76.7	50% Co–Cr	60.0
75% Al	—	75% Co–Cr	—
TiC–25% Co	—	TiC–25% Ni	87.5
50% Co	90.7	50% Ni	—
75% Co	97.3	75% Ni	80.0
TiC–25% Fe	73.5	TiC–25% Co–Cr	73.7
50% Fe	—	50% Co–Cr	—
75% Fe	77.7	75% Co–Cr	75.6

Table II. Relative densities of cermet systems. Optimum values for compositions as sintered at 1350 degrees centigrade or 1400 degrees centigrade.

75 to 85 per cent. The results of the density determinations and porosity studies supported the expected correlation of the two properties.

Figure 1 represents microstructures of 75 per cent TiC-25 per cent Ni, 50 per cent TiC-50 per cent Fe, and 50 per cent TiC-50 per cent Co at 200 diameters. The photomicrographs show decreasing porosity for increasing relative densities which were 72.9, 90.7, and 97.3 per cent, respectively. Preliminary attempts with Co-Cr-Mo as binder for Al_2O_3 and TiC were unsuccessful for the treatments used. The low relative densities experienced with Co-Cr-Mo as a binder probably can be attributed to improper treatment conditions.

In general, density increased with binder content, with the highest relative densities occurring at the 75 per cent volume binder content. The optimum sintering temperature was 1,350 degrees centigrade for all systems excluding cermets composed of 50 per cent TiC-50 per cent Fe, 50 per cent TiC-50 per cent Co, 75 per cent TiC-25 per cent Ni, and 75 per cent TiC-25 per cent Fe. The latter systems developed better properties when sintered at 1,400 degrees centigrade.

The sintering data indicate that a direct relationship may exist between sintering temperature and the degree of brittle dispersion. Increasing sintering temperatures would be required for cermet systems of increasing dispersed phase or decreasing binder content. Sintering time was kept constant for a period of two hours for preliminary investigations. It is expected that increased sintering times will play an important role in the development of superior properties in several cermet systems.

METALLOGRAPHIC examination was performed on all cermet systems investigated. The systems composed of TiC bonded with Fe, Ni, and Co are typical examples of the cermet structures encountered. Microstructures of specimens representing the systems 75 per cent TiC-25 per cent Ni, 50 per cent TiC-50 per cent Fe, 25 per cent TiC-75 per cent Fe, 50 per cent TiC-50 per cent Co, and 25 per cent TiC-75 per cent Co will be discussed in their respective order. Figures 2a and 2b represent the 75 per cent TiC-25 per cent Ni structure sintered at 1,350 degrees centigrade for two hours. The porosity, or voids, are the black areas in the photomicrograph taken at 500 and 1,500 diameters. The angular TiC grains (grey areas) are well dispersed within the white, textured Ni matrix. Growth of the TiC grains was experienced at the expense of the smaller particles during the sintering treatment. The particle size of the TiC powder ranged between 5 to 10 microns.

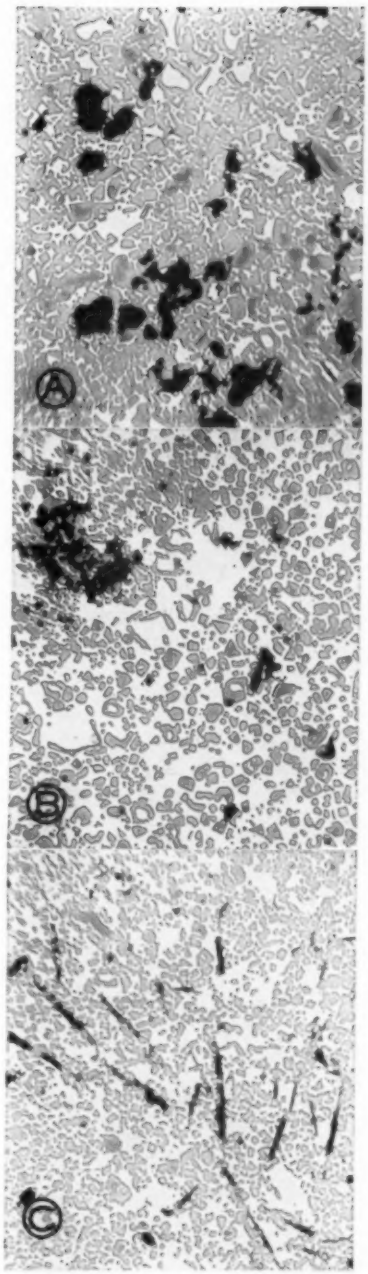


Fig. 1. Photomicrographs of sintered cermets, polished and etched, 200X: (a) 75% TiC—25% Ni; (b) 50% TiC —50% Fe; (c) 50% TiC—50% Co.

1. One per cent acid lubricant added to all compositions.
2. Mixtures ball-milled for 4 hours.
3. Compacts pressed at 30,000 psi.
4. Specimens sintered in hydrogen at temperatures from 1250 to 1400 degrees centigrade for 2 hours.

Table III. Screening treatment used for all compositions in experimental tests.

As sintered, the structure exhibited grain sizes between 1 to 20 microns. This particular grain growth phenomenon in the TiC-Ni system has been noted by M. Humenik, Jr., and N. M. Parikh. They attributed the grain growth process to the incomplete wetting of the carbide by the Ni with a resulting mechanism of coalescence occurring between the individual carbide particles.

THE mechanism of coalescence can be seen in Figure 2b where TiC grains are barely touching with a lack of Ni metal separating the grains. The voids in the microstructure are also related to the incomplete wetting by the Ni and therefore incomplete bonding within the cermet system. Coring was found to be present within some of the TiC grains (the darker areas within the grains); however this effect cannot be explained at this time.

The 50 per cent TiC-50 per cent Fe and 25 per cent TiC-75 per cent Fe systems are shown in Figures 4a, 4b, 4c at 500 and 1,500 diameters. The TiC grains are seen as spheroids in the 50 per cent TiC-50 per cent Fe system (Figure 4b), while these grains appear in sharp angular shapes in the case of the 25 per cent TiC-75 per cent Fe system (Figure 4c).

Some grain growth took place in the TiC-rich system as compared with the high Fe cermet. The specimens were sintered in graphite boats so that carbon could readily diffuse into the cermet briquettes. This effect is noted by the large areas of ferrite (white) and the very fine pearlite areas (white and black laminar structure) in Figures 4b and 4c. The TiC grains are evenly dispersed in both the ferrite and pearlite areas.

The 50 per cent TiC-50 per cent Fe system exhibits a peculiar preferred orientation. The preferred orientations

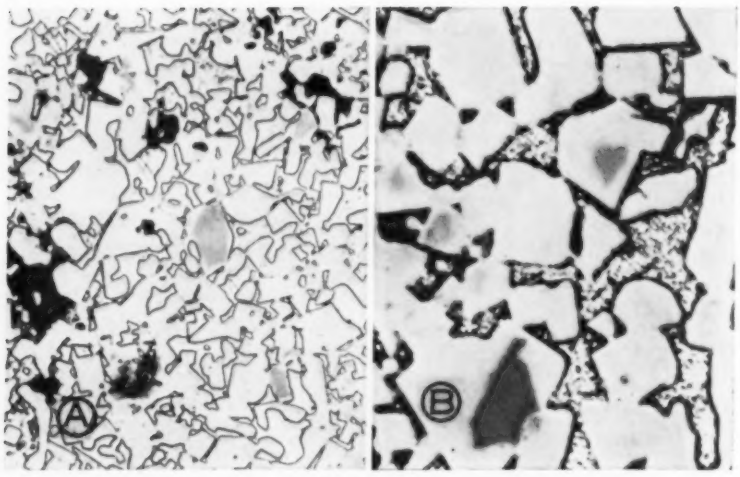


Fig. 2. Photomicrographs of sintered cermets, polished and etched (a) 75% TiC—25% Ni, 500X; (b) 75% TiC—25% Ni, 1500X.

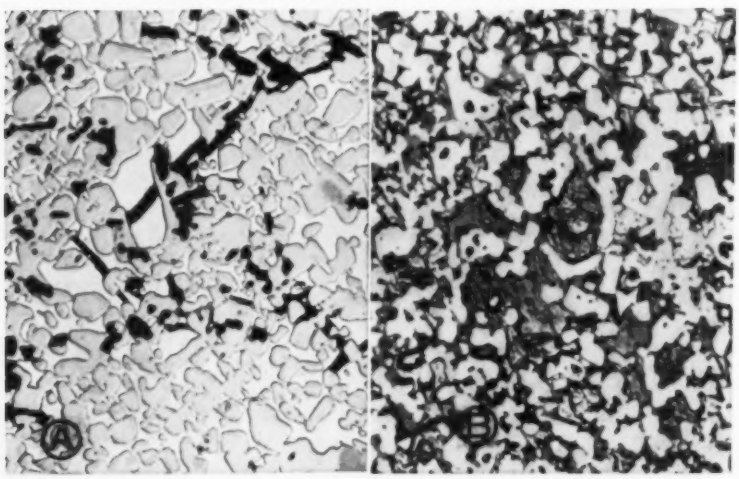
are perhaps due to the path of least resistance of the diffusing atoms to the internal areas of the specimens from the graphite boats. Figures 2a and 2b show such preferred orientation and the possible passage of the carbon leaving the ferrite structure after the specimen has cooled.

The 50 per cent TiC-50 per cent Co and 25 per cent TiC-75 per cent Co systems are represented at 500 diameters in Figures 3a and 3b, respectively. The porosity is much greater in the 50 per cent TiC-50 per cent Co system and may be attributed to unusually high cooling stresses in the Co phase. Cracks result from these cooling stresses and propagate through the Co phase, the cracks being identified as the black areas in the photomicrograph (Figure 3a). The grey areas are the TiC grains, and the Co binder phase appears white. Apart from cracks or voids, the Co phase is continuous and surrounds the TiC dispersion.

The 25 per cent TiC-75 per cent Co system exhibits a similar microstructure with the exception that porosity is practically nonexistent. The TiC grains are well dispersed in the 25 per cent TiC-75 per cent Co system, but, on the other hand, some segregation of the Co phase is present within the structure (Figure 3b). The segregation may be eliminated with a more thorough mechanical mixing of the TiC and Co powders.

The TiC-Co cermet was the most successful system encountered during this study in view of the high strengths developed. Strength increased with increasing Co content, a property similar to all other systems with the exception of the Al_2O_3-Al system. These results were anticipated since Co is known to wet and bond favorably with titanium carbide and tungsten carbide. The merits of the TiC-Co system with additions of TaC and NbC have been investigated for low volume percentages of Co. Room-temperature strengths reaching 190,000 p.s.i. were reported. Transverse rupture strengths of 230,000 p.s.i. were reported for compositions of 32 per cent TiC, 60 per cent Co, 8 per cent Cr_3Cr_2. The Co percentage becomes limited by the desired application and temperature at service. The softening temperature decreases with increasing binder content, but thermal shock characteristics and ductility would show marked improvement.

Fig. 3. Photomicrographs of sintered cermet specimens, polished and etched, 500X: (a) 50% TiC—50% Co; (b) 25% TiC—75% Co.



The TiC-Fe cermets developed strengths between 75,000 p.s.i. and 90,000 p.s.i. for compositions of 25 per cent TiC-75 per cent Fe content. The increase in strength with increasing binder content again was noted. The literature did not yield any data with respect to the TiC-Fe system and therefore comparison of the results with parallel or similar investigations was not possible.

It is evident that superior strength properties could be obtained by improving the treatment conditions, thereby decreasing the high porosity observed. The use of carbonyl Fe or a fine grade of electrolytic Fe powder could lead to greater strength values. Hydrogen-reduced Fe powder was combined with the high-grade 325 mesh TiC powder for the specimens prepared in this current study.

Strengths of TiC-Ni cermets have been reported higher than the values determined in these tests. Strengths varied between 10,000 p.s.i. to 65,000 p.s.i. The lower strengths are attributed to processing techniques. A standard set of treatment conditions had been established. All of the cermet compositions were pressed at one pressure and sintered at the same temperature with similar sintering times. Future work with TiC-Ni compositions will be preceded by initial deoxidation and annealing treatment of the Ni powder.

Al_2O_3 cermets were bonded with three of the available commercial Fe powders—electrolytic Fe, hydrogen-reduced Fe, and carbonyl Fe. The results

of these tests varied over a wide range from negligible values to strengths as high as 117,000 p.s.i. The high strengths occurred where 75 per cent by volume of carbonyl Fe was used as a binder.

Electrolytic and hydrogen-reduced Fe developed extremely poor results in comparison with the carbonyl Fe in all volume compositions investigated. The appreciable difference in strength most likely can be attributed to the very fine particle size of the carbonyl Fe powder. The carbonyl Fe particles approach the size of the Al_2O_3 powder particles leading to favorable mechanical mixing conditions.

Al_2O_3 cermets bonded with Co powder developed the highest strengths attained by oxide dispersion in the extent of this investigation. Transverse rupture strength increased with increasing binder content from low values to 181,500 p.s.i. The low strengths are due to poor volumetric combinations and poor bonding for the sintering conditions used.

THE strength of 181,500 p.s.i. occurred when the cermet composition was sintered at 1,350 degrees centigrade for two hours. A high grade of commercially pure Co powder with a fine particle size was used to ensure good mixing between the phases. The bonding characteristics were far superior between the Al_2O_3 and Co as compared with other systems studied.

Al_2O_3 bonded with Al was investigated at the standard conditions for all experiments even though it was expected that the Al would melt out of the compact during the sintering operation. Compositions of high binder content exhibited partial to total melting leaving a powdery cake of Al_2O_3. However, as the binder content decreased, several compacts of 50 per cent Al_2O_3-50 per cent Al developed strengths between 7,500 p.s.i. and 17,000 p.s.i.

A valuable material might be developed if compositions in this range were sintered in an oxidizing atmosphere. Oxide-oxide bonds would be developed leaving an intimate Al_2O_3 structure.

Tests with the Al_2O_3-Co-Cr and TiC-Co-Cr cermets did not yield data comparable to the Co or Ni systems. P. Schwarzkopf and R. Kieffer report that, while the results of work with pure Cr as a binder have not been outstanding, work with Co-Cr, Ni-Cr, and Co-Ni-Cr alloys have led to commercial products.

Fig. 4. Photomicrographs of sintered cermets, polished and etched (a) 50% TiC—50% Fe, 500X; (b) 50% TiC—50% Fe, 1500X; (c) 25% TiC—75% Fe, 1500X.

The properties of the cermet systems were found to be related directly to the observed microstructures. Superior strengths were developed with Co as a binder for TiC and Al_2O_3. Fe and Ni exhibited promising properties along with the Co systems.

These systems with selected treatments would form the nucleus of materials to be developed in subsequent phases of this basic investigation. It is believed that further experimentation with alloy additions in the binder will provide significant improvement in the cermet materials.

There are some general considerations which play an important part in this endeavor. Proper choice of raw materials becomes an essential phase in cermet development. The commercial fabricators must strive to provide ceramic and metallic powders of high purity. These powders must have very small particle sizes where both components are preferably matched. TiC and Al_2O_3 powder size should be decreased to approximately 1-micron diameter as opposed to the available 5- to 10-micron particles.

Smaller particles greatly affect the mechanical mixing characteristics of any set of powders which in turn benefits the sintering mechanism. Diffusion occurs at a greater rate which decreases the necessity of a severe sintering treatment. Dispersion of the hard particles occurs evenly which results in a superior microstructure.

EACH metal and ceramic powder has its own particular pressing characteristics. The standardized pressure of 30,000 p.s.i. was chosen as the average optimum pressure from initial compacting attempts. Once a system ephibits promising properties, the treatments have to be carefully reviewed and subjected to a critical investigation.

Ceramics are pressed at low pressures in the range of 10,000 to 20,000 p.s.i. while pressures for metal powders vary from 20,000 to 200,000 p.s.i., and arriving at optimum compacting pressures becomes an experimental problem rather than a theoretical consideration.

The author wishes to acknowledge the assistance and guidance given by Dr. Bennett Bovarnick under whose direction this investigation was conducted.

Explosives Crystallization

Propellants, primers, pyrotechnics, and high explosives such as RDX and TNT have been greatly improved by the development of processes to control crystal growth and stability effectively during production

Dr. Walter C. McCrone

THE physical properties of explosives (loading density, particle size and shape, solidification rate, detonation velocity, impact sensitivity, etc.) are determined to large extent by their crystallographic properties. The increased amount of RDX in cyclotols as compared with Composition B is due to controlled crystallization conditions which give the proper size distribution and shape of the RDX crystals. The same situation exists with perchlorate-rubber propellants and with plastic explosives such as Composition C.

Different crystal forms of a given explosive can behave as if they were totally different explosives. HMX is a good example of this: the beta form of HMX is a safe high explosive whereas the other polymorphic forms of HMX are so sensitive they are potentially useful as primers. The care taken to be sure that alpha lead azide is formed rather than the beta form is another example of the importance of controlling crystal structure.

Many times relatively subtle crystal properties can be of crucial importance. Lead azide, for example, can detonate spontaneously but it has never been observed to do so except when it was crystallizing from solution. The more rapidly a crystal of lead azide grows, the more strained the crystal lattice. As growth continues, the strain builds up until it exceeds the strength of the crystal and spontaneous cracks release energy sufficient to initiate detonation.

The cure for this is to grow lead azide crystals so slowly that the strain is relieved as the crystal grows. Large crystals of either alpha or beta lead azide up to one inch in length can be grown if the growth rate is slow enough.

There is no critical size above which lead azide spontaneously detonates. There is, however, a critical crystallization velocity above which the growing crystal will detonate spontaneously.

Crystal properties and impact sensitivities of the four HMX polymorphic forms.

	Beta form	*Alpha form*	*Gamma form*	*Delta form*
System	Monoclinic	Orthorhombic	Monoclinic	Hexagonal
Habit	Equant	Rods & Needles	Plates	Rods
Refractive indices	1.589	1.562	1.537	1.566 (E)
	1.595	1.563	1.585	1.607 (W)
	1.773	1.735	1.663	
	1.92	1.87	1.82	1.78
Density impact sensitivity RDX (55 cm.)	33	2-30*	1-20*	1-10*

* *Depends on crystal size and shape; in general, small crystals are less sensitive.*

TO illustrate the importance of crystal properties I want to discuss in some detail two specific explosives problems involving crystallography. The first of these is RDX. Early in 1941 I was a graduate student at Cornell University and a teaching assistant in chemical microscopy. One day a fellow graduate student brought in some crystals to examine microscopically. These were associated with a hush-hush NDRC project, and he was quite secretive about the whole thing.

He did, however, have enough trouble seeing what he wanted to permit me finally to peek at the crystals. In a few minutes I could tell him there were two components present, and he became very much interested.

I later learned that we were looking at samples of Bachman process RDX which contained around eight per cent HMX. This was at a time when the United States was trying desperately to get RDX into production using the Bachman rather than the Woolwich process, but the high and unpredictable impact sensitivity of the Bachman process product was endangering the whole project.

I spent considerable time studying different pilot plant samples of RDX and was soon able to characterize the

crystals of RDX and HMX and to suggest that HMX was the sensitive agent in the Bachman RDX. At this point I found myself suddenly working for NDRC and during the next year had an opportunity to study HMX in detail. It turned out to have four different polymorphic forms each with different crystal properties and with different impact sensitivities, as shown in the accompanying table. The latter also were found to vary for a given polymorphic form with crystal size and shape.

A CAREFUL study of the stability of these different crystalline forms of HMX showed each could be obtained by careful control of the crystallization conditions. Furthermore, under a certain easily obtained set of conditions the HMX would crystallize in the beta form and as such would not significantly sensitize RDX. This work was completed in time to become a part of the Holston Ordnance Process for the manufacture of RDX.

The second problem of crystallographic interest is the pouring of TNT. The time-honored process for pouring TNT and Composition B with its pouring, probing, repouring, reprobing and repouring ritual is too well known to justify description. In 1952, Mac Ross, a product of British reverse lend-lease, had the idea that a study of the crystallization of TNT would lead to an improved production method for all calibers of high-explosive rounds then produced by pouring.

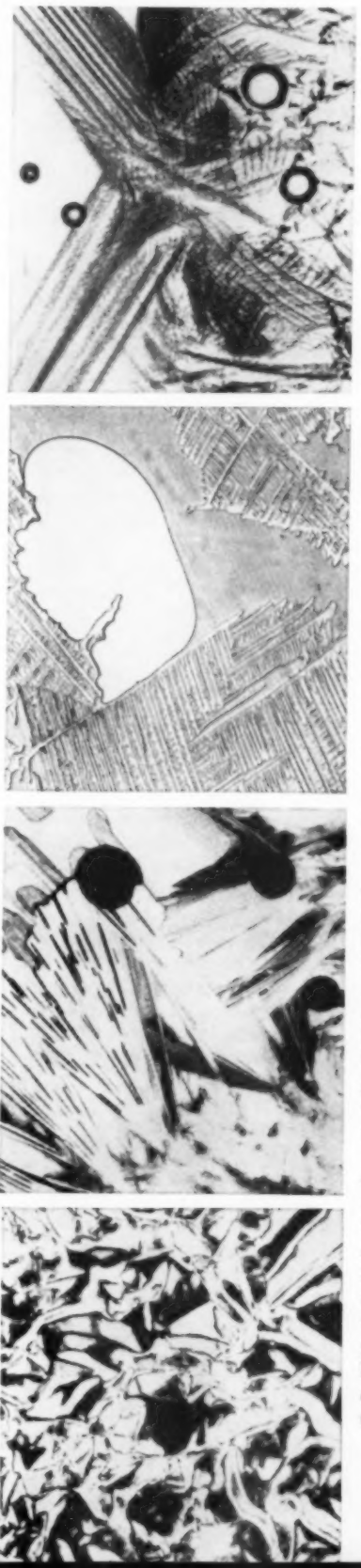
Accordingly he came to the Armour Research Foundation of the Illinois Institute of Technology and suggested we submit a proposal covering his ideas. In due time the project was approved and work began. We made a careful microscopic study of TNT and found that an improved process could be based on the following two ideas:

1. All air, which is very soluble in a TNT melt, must be removed before crystallization by melting the TNT under vacuum or by holding the TNT melt under vacuum with agitation for thirty to sixty minutes.

2. The round, once poured, must be kept hot at the top as it cools and crystallizes from the bottom up. A reservoir supply of melted TNT must be available in the funnel to make up for the eleven per cent shrinkage during crystallization.

The next step was to clear up a few engineering details. This required several years of intensive and careful work by Silas-Mason personnel. Significant help in the whole project came from many sources; Jim Ward, then at L.O.P. was the first to suggest to us the use of the Votator which has been so successfully developed by I.O.P. and is now called simply the Crystallizer.

These examples of crystal studies in the explosives field are only a token representation of the possible applications that could have been chosen. Propellants, primers, pyrotechnics, as well as high explosives have been greatly improved and will be much further improved by closer crystal control.



Highly magnified slides show crystallographic structures of the high explosives Ednatol (top), Explosive D, Composition B, and Aristowax (bottom).

Dr. McCrone is director of McCrone Associates, Chicago, Ill. This article is based on an address given by Dr. McCrone before a recent meeting of the Loading Section, A.O.A. Bomb, Warhead and Artillery Ammunition Division, held in Burlington, Iowa.

EDITOR'S NOTE.—The use of high explosives in military shells is of historical interest as indicated by the following passage from an article by Aiken Simons published in the July-August 1934 issue of ORDNANCE:

"The development of commercial explosives containing nitroglycerin and/or nitrocellulose led to the idea of their use as a bursting charge for projectiles. Tests were made at Sandy Hook in 1883 with a blasting gelatin containing 4 per cent camphor which was successfully fired without damage to the gun; but when a gelatin of 92 per cent nitroglycerin and 8 per cent nitrocellulose was tried in 1884, a 3.2-inch gun was destroyed.

"A number of inventors tried to overcome the difficulty. In one plan, glycerin and acid were placed in the projectile, to be mixed by the shock of the discharge, the nitration taking place during the time of flight. While the plan worked, the amount of inert matter was so great that the projectile had no greater force than one loaded with black powder. The difficulty was finally overcome by using compressed air as the propelling force."

Jewel Bearing Dilemma

While modern weapons have greatly increased the demand for these precision parts there is only one U. S. plant capable of their production in the quantities that would be needed in an emergency

Robert Schwebel

THE common denominator of nearly all fire-control systems—the tiny instrument jewel bearing—today represents an "uncommon" and vitally significant procurement problem. Procurement of sufficient jewel bearings for gyroscopes, meters, chronometers, and other precision instruments under normal conditions offers no problem. But, in the event of a national emergency, procurement of jewel bearings will be one of our most critical mobilization problems.

There is a Government stockpile of these bearings, and some of them would, of course, be usable. However, rapidly changing requirements and lack of standardization among precision instrument designers and users would require a continuing supply of bearings to meet production needs. Virtually the only source of jewel-bearing production available to the military in an emergency mobilization situation is a pilot facility managed and operated for the Government by the Bulova Watch Company at Rolla, N. Dak.

THE Government recently adopted a policy urging weapon systems managers and contractors to utilize the Rolla plant's facilities for designing and manufacturing bearings needed for current and specialized requirements. This policy emphasizes the necessity for maintaining a domestic jewel bearing plant abreast of current design needs. It does not make possible, however, a significant expansion of production or the designing of improved instrument jewel bearing fabricating tools and machinery.

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Operations under this policy have put the Government agencies charged with defense and mobilization in one of those damned-if-you-do and damned-if-you-don't situations. Assuring American instrument makers a source of jewels is not simply a problem—it is a dilemma. Several basic factors contribute to this dilemma:

1. It has not been economically feasible for American industry to establish a domestic instrument jewel bearing industry because of labor cost differentials and the lack of available trained technicians and craftsmen.

2. Jewel bearing production requires a skilled and highly trained labor force which takes years to develop, as well as a variety of uniquely specialized machinery and tools.

3. There is no adequate all-purpose substitute for the jewel bearing known to research or industry.

4. During peacetime, imports can adequately supply defense needs as well as commercial requirements for watches and other precision timepieces—with the exception of some unique or high-high-precision requirements.

5. In the event of a national emergency, all our foreign bearing sources could be cut off or destroyed. When supplies were cut off in World War II, aircraft production was brought to a virtual standstill for months. Measures taken to solve the problems then would not suffice in the third world war or another large-scale brush-fire war.

CONSUMPTION of jewel bearings for defense products has increased astronomically with each new development in instrumentation for measuring, indicating, and control. Missile systems and space-age projects demand an ever-growing consumption. Fire-control systems today require as many jewel bearings per system as battleships did a decade ago. Development of production machinery and the training of personnel is not an M-day-plus proposition—an all-out effort to establish domestic sources merely to meet current defense requirements would take months.

The principal and underlying causes behind many of the factors contributing to the dilemma are coincident with the history of watchmaking and the jewel bearing industry. Although drilled jewels were used more than 2,000 years ago, it was not until the mid-nineteenth century that mass production of jewel bearings was necessary.

Switzerland is the center of the world's precision jewel bearing industry and the world's chief manufacturer and exporter. Jewel bearing production was established by the Swiss as a "cottage" industry in which families worked

to produce the finished product. This type of production was typical of the Swiss watchmaking industry and benefited by low labor costs and a high degree of father-to-son skilled craftsmanship.

The Swiss people—world-famed for their watchmaking and precision instrument craftsmanship—naturally want to safeguard their position as the chief source of these tiny bearings. As a result, manufacturing techniques and production equipment are zealously controlled.

THE only other nation today with a productive capacity that approaches Switzerland's is the Soviet Union. They are not dependent on outside sources of supply. Their productive capacity sharpens the edge of our dilemma.

The Department of Defense and the Office of Civil and Defense Mobilization recently reiterated the need for additional support for at least a pilot-plant jewel bearing facility in the United States and a reservoir of trained jewel bearing craftsmen and technicians capable of building and improving precision machinery and instrumentation needed for successful jewel bearing production.

The Office of the Assistant Secretary of Defense (Supply and Logistics) several months ago reported that "the Director (of Civil and Defense Mobilization) has deemed this facility to be essential to the mobilization base."

The "facility" he referred to is the jewel bearing manufacturing plant located at Rolla, N. Dak. Bulova manages all aspects of the plant's operation under a dollar-a-year, cost-plus-fixed-fee contract.

Procurement problems relating to precision jewel bearings are being studied by the Instrument Jewel Bearing Section of the American Ordnance Association, and members of the Section have offered their cooperation to the Government in devising a set of standards for the design of such bearings. The Section is part of the A.O.A. Fire Control Instrument Division and is made up of instrument jewel bearing users, importers, and management of the Rolla plant.

Millions of instrument jewel bearings are used in this country every year. They are found in such devices as gyroscopes for missiles and space craft, fire-control systems for tanks and ships, navigation instruments for aircraft and submarines, chronometers, and many other precision instruments in which friction would drastically reduce the effectiveness and accuracy of the device. In fact, most of the precision instruments considered essential to our military program could not exist without jewel bearings.

Jewel bearings are tiny synthetic sapphires or rubies, roughly the size of a pinhead. They are drilled, shaped, and polished to tolerances of hundred-thousandths of an inch. They are used wherever a surface is needed against which moving parts of an instrument must move or rotate with a minimum of friction, vibration, and wear. Yet they must be able to withstand pressures of as much as twenty tons per square inch.

A typical use of precision jewel bearings is found in the hermetic integrating or "floated" gyroscope used in ballistic missiles. Friction is reduced—and, consequently, accuracy and usefulness improved within this type of gyro—by several magnitudes through the use of tiny jewel bearings that serve on either end of the gyro gimbal which is floated within the gyro case by a sirupy fluid.

The gimbal's carbide pivots that rotate within the jewel bearings are typically about 0.016-inch in diameter. The tiniest defect in the jewel bearing would destroy the gyro's ability to measure minute angular changes.

WITHIN the past few years—generally since the close of the Korean conflict and the accompanying increased production of more precise instruments incorporating jewel bearings—American consumption has been at about 200 million bearings a year. Much of this total has been imported into the United States from Switzerland in the form of jewels already set in watch movements; some have been imported from Switzerland and other countries as loose jewels (some for watches, many

This 26-spindle drilling machine with .005-in. boring wire, can lap holes in sapphire disks to tolerances of .0002-in.

After drilling, jewels are strung on wire to open holes and achieve polish.

for instruments), and only one per cent of the total is made in the United States.

End consumption by the U. S. probably is the largest in the world (although it may be nearly equaled or even exceeded by Russia) yet we produce less than half of one per cent of the world's supply. Accurate estimates are difficult to make because of the disparity of consumption and production figures from other nations.

Consumption during World War II for instruments and military timepieces amounted to an average of about 70 million a year. It has been estimated that consumption during another war would easily surpass 100 million and approach 200 million. This figure includes jewels for watches as well as for military instruments.

In no other respect is the United States so dependent on an outside source for so essential a commodity or material. Senate Preparedness Subcommittee hearings offer ample reports and testimony describing the criticalness of a jewel bearing shortage in event of war.

THE lack of a jewel bearing industry in the United States became a matter of great concern to the military establishment in mid-June of 1940 when France fell and the Swiss source was cut off. Britain's urgent request to this country for jewel bearings resulted in further alarm among the military and defense agencies. Representatives of domestic watch companies together with representatives of meter and aircraft instrument makers were called to Washington and met under the auspices of the National Defense Council. Concerted planning was initiated for the establishment of an American instrument jewel bearing source.

Watch industry spokesmen pointed out that instrument jewel bearings were extremely difficult to manufacture and that there were no trained personnel in the United States. Establishment of a domestic source would require importing skilled technicians from Switzerland. Through efforts of the Bulova Watch Company two Swiss experts—one a chemist and the other a designer of machines needed to produce jewel bearings on a mass-production basis—were brought to this country where they arrived just one week before Pearl Harbor.

Because the two were unable to take with them any notes or drawings, they had to begin the laborious task of setting up an entirely new industry from memory, but they had a production line ready to go at Bulova in seven months.

Government agencies had underestimated the need for domestically produced jewel bearings because the nature of warfare changed so quickly and dramatically during the early years of World War II. It wasn't until mid-1943 that the American watch companies were able to mass-produce bearings in sufficient quantity to keep pace with the production of instruments, meters, and fire-control systems.

In the meantime, the Bulova company managed to hand-make some 1,200 precision tools and machines for jewel bearing manufacture since conventional machine-tool makers were unable to cope with the small tolerances required.

These tiny bearings—2,000,000 could be carried in a Mason jar—were considered so valuable during 1943 and 1944 that special couriers rushed them from the inspection lines to the instrument makers, and great quantities were smuggled out of Switzerland despite the German embargo.

Examples of the voracious appetite for bearings needed within individual weapons include these estimates from a War Production Board report: 17 for a military timepiece, 350 for a bombsight, 1,500 to 4,000 for an aircraft, and 5,000 for a battleship.

After World War II the Government, having weighed the warnings of jeweled watch manufacturers and military spokesmen about letting instrument jewel bearing know-how and technology deteriorate, lost interest in sustaining a domestic jewel bearing source until the Korean conflict broke out.

SUBSEQUENT to the Korean campaign, however, the Department of Defense and the Army determined that the establishment of a pilot plant for continuous training of a nucleus of technicians and craftsmen and the production of jewel bearings was desirable. This decision was prompted by the realization that stockpiling jewel bearings would not suffice in the event of a national emergency because of the rapid obsolescence of particular bearing designs.

This obsolescence was not intrinsically attributable to the bearings but rather to the great strides in design improvement being made in instruments and fire-control components and systems. Magnitudes of improvement in accuracy, durability, and precision in gyros, recorders, gages, timers, and other components placed an even heavier emphasis on the need for bearing accuracy and new designs. Reliance on stockpiles alone would have been impracticable and unrealistic.

In 1952 the Army asked for bids to establish a jewel bearing plant in the United States for purposes of production and training of personnel. Several watch companies entered bids, and the contract was awarded to the Bulova Watch Company in October of that year for the "furnishing of personnel, labor, equipment, supplies, services, and maintenance for activation and habilitation . . . for the manufacture of jewel bearings."

Within five months, under Bulova's direction, a plant was constructed and equipped, and training was com-

menced. The company's unique contribution to the facility consisted of technical experience in the design of jewel bearings and their production equipment, as well as in the intricacies of their manufacture. Bulova assigned its two key jewel bearing specialists to the project and, since no others were available in this country, brought three more over from Switzerland.

The plant was established a few miles from the Turtle Mountain Indian Reservation near Rolla and was designated as the Turtle Mountain Ordnance Plant.

There were several reasons why the plant was established at Rolla: (1) utilization of the dexterity of the Chippewa Indians on the near-by reservations, (2) dispersion, (3) lack of a need to "untrain" a labor reservoir of skills acquired in a different field, and (4) the occasion to establish a year-round employment opportunity for the Indians who would otherwise have been forced to continue acceptance of Government support payments.

More than 10 million jewel bearings of many varieties have been manufactured at Rolla, and the current annual production rate is over 2 million. Production could be doubled virtually overnight, and possibly tripled within several months by adding extra shifts. Perhaps more important than production is the reservoir of experience being acquired by the employees as they learn to make new types of jewel bearings and to cope with the multiplicity of problems inherent in their manufacture.

THE contract has been administered since 1957 by the General Services Administration as an Office of Defense Mobilization function, and Bulova has continued to operate the plant on much the same basis as was set down in the original contract—including the CPFF provision for a dollar-a-year fee for the company.

Employment at the Rolla plant is about 150, and more than 85 per cent of the production employees are Indians from the reservation and near-by town. There are about 5,000 Indians on the reservation, and about 20 per cent of these now depend directly on the jewel bearing plant for their income. Nine of the twelve supervisors are Indians.

At the specific direction of the Department of Defense and the Office of Civil and Defense Mobilization, the plant's emphasis has been on the design and production of unusual and otherwise unobtainable types of instrument jewel bearings for specific defense product needs as well as training coincident with the plant's day-to-day operations.

At the same time, the plant is meeting or exceeding its production quota of bearings for GSA's stockpile of strategic and critical materials. These stockpiled bearings are predicated on current and potential needs for jewel bearings designed for specific defense products.

Most of the equipment and machinery in use at Rolla came from Government surplus left over from World War II. Rolla technicians have improved their equipment (and in some cases completely rebuilt it) and have designed new production techniques.

While some money has been allocated for the improvement of machines already at the plant, none has been made available for the purchase or development of modern jewel bearing manufacturing equipment using recently developed techniques, such as ultrasonics and electron bombardment, which the Swiss are known to be using. In fact, the present contract with GSA specifically excludes expenditures for research and development.

Aside from the basic procurement dilemma, there are three basic problems that make manufacturing a jewel bearing an extremely difficult operation. Its tiny size makes it difficult to see and manipulate. Tolerances on finishing and polishing are infinitely small—sometimes measured in millionths of an inch. Hardness of the sapphire and the presence of diamond powder cause unique tooling and production-machinery maintenance problems. As many as forty separate manufacturing operations are needed to turn jewel "blanks" (flat and circular-shaped pieces of synthetic jewels) into finished bearings.

THERE are eight types of precision instrument jewel bearings. The Rolla plant is qualified to produce any of these types in a variety of quantities and sizes. The most common types and their particular uses are the "cup" and "vee" bearings to support conical pivots, "ring" bearings to support cylindrical pivots, and "end stone" bearings to provide support against the end of a cylindrical pivot.

Recognizing that only through actual production experience can the skills learned by the Rolla employees be retained and improved, the Department of Defense, in June 1958, asked the logistics and material sections of the three military services to assure that the greatest possible number of jewel bearings consumed for military instruments are procured from the Rolla jewel bearing manufacturing facility.

The importance attached to the maintenance of the Rolla plant was reiterated in April this year when the Assistant Secretary of Defense (Supply and Logistics) notified the military services: "It is intended that Rolla-made jewel bearings be incorporated in instruments manufactured for military use to their fullest extent. The only reasons for utilizing jewel bearings from other sources should be that of quantity, quality, or that schedules cannot be met."

String of sapphire jewels is given rough outside diameter grinding.

Weather to Order

The climatic facility at Frankford Arsenal provides the greatest flexibility in both rainfall and sunshine simulation as well as the most accurate control of these environments ever achieved

Fred Hermann and Seymour Sternbach

THE years since World War II have brought such drastic improvements in ordnance and ground-support equipment that today's extremely complicated military hardware costs many times as much as comparable equipment used during the last war. If only to protect the huge investments involved, the cost of modern equipment reemphasizes the need for design and selection of materials that can withstand the environmental extremes that will be encountered in worldwide operations.

Field testing for such conditions is, for reasons of time alone, impractical. Too few geographic locations produce the extreme conditions needed for proper testing, let alone produce them in a concentrated period of time. Nor is there any possibility of obtaining tests with any repetitive reliability. Nature does not reproduce a required number of days of identical weather on order.

So the only practical solution has been the accurate simulation of rain and sunshine in the laboratory. This makes possible testing under closely controlled conditions that can be repeated as often as required to determine the adequacy of design and the performance of materials under test.

IT was against this background of need that the rain-and-sunshine test facilities were installed some time ago at the Frankford Arsenal near Philadelphia. Some of the engineering problems which were solved in the design and construction of these facilities almost certainly will lead to further advances and refinements in the art of environmental testing.

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At present, requirements for producing rain and sunshine in accordance with military specifications such as Mil-E-5272 and others are limited as compared with natural conditions. Current rainfall specifications call for an intensity of from 3 to 5 inches an hour to be produced by spray nozzles with the water temperature maintained between 51.8 and 68 degrees Fahrenheit. The chamber air temperature is to be maintained between 68 and 86 degrees Fahrenheit.

The sunshine requirements are similarly very brief. They call for a total intensity of 100 to 120-watts per square foot with a spectral distribution consisting of 50 to 60 per cent of the total energy in wave lengths above 7,800 Angstrom units (infrared band), 4 to 6 per cent in wave lengths below 3,800 Angstrom units (ultraviolet band), with the remaining percentage being visible energy. The test chamber air is to be maintained at a temperature of 113 degrees Fahrenheit during the sunshine tests.

This is the sum total of existing specifications which are, of course, very limited. They represent basically one condition each of rainfall and sunshine, which hardly represents the environments under which ordnance equipment is expected to operate. It has been determined on numerous occasions that variations in the extremes encountered can be more damaging than a continuous steady-state condition.

TO accomplish the rainfall requirements under the above specifications requires no more than one or more spray nozzles which might be fixed or rotating, having a given output at a controlled water pressure directed at the test plane. The sunshine specification can be achieved with a combination of lamps whose total output averages the required output without any consideration for uniformity of distribution or ability to vary total intensity outside the narrow range indicated.

From the above methods it can be seen that there are many uncontrollable factors which cause deviations in the attempt to simulate natural rainfall. The use of spray nozzles cannot produce uniform coverage on the test plane because of the inherent nature of the design of the nozzle. That is, solid-cone nozzles produce high-intensity levels at the center of the cone with lesser intensity levels at the outer perimeter. A hollow-cone nozzle produces the reverse effect.

Rotating these nozzles does not solve the problem inasmuch as the same non-

uniformity exists as just outlined and introduces another incongruity in that the nozzles offer intermittent coverage of the test plane.

It also can be seen that there is little or no control over the droplet size produced by spray nozzles since the size of the droplets is predetermined by the water pressure required to produce certain quantity flows from these nozzles. The use of spray nozzles limits the variability in intensity of flow because moderate changes in pressure required to increase output of these nozzles cause the water to atomize rather than fall in droplet form.

The deficiencies in simulating sunlight with combinations of various lamp sources are much the same as the corresponding deficiencies of producing rainfall. These lamp combinations produce a nonuniformity of light intensities as well as uneven spectral distribution over the test plane. The fixed position of these lamps limits the variation of intensity level which should follow a pattern of increasing and decreasing intensities as the day progresses.

FOLLOWING is a definition of the new limits and tolerances which were used in the design of an environmental chamber to simulate natural rainfall and sunlight more accurately:

"Provide simulated rainfall of controllable intensities varying from ½-inch per hour to 24 inches per hour on an 8- by 10-foot measuring plane at floor level, with random droplet sizes varying between ½-mm. and 6-mm. diameter, and with temperature of the rainwater controllable at any specified temperature between 11 and 20 degrees centigrade. The intensity of the rainfall shall be controllable in increments of ½-inch per hour from ½-inch to 4 inches per hour, and in 1-inch-per-hour increments thereafter, to a maximum of 24 inches per hour.

"The intensity distribution pattern within the 8- by 10-foot area shall not deviate more than plus or minus ½-inch per hour up to 4 inches per hour, nor more than plus or minus 10 degrees Fahrenheit of the specified value for intensities from 5 inches per hour to 10 inches per hour and no more than plus or minus 1-inch per hour from 11 inches per hour to 24 inches per hour. Measurement of rainfall intensity shall be by U. S. Weather Bureau rainfall gauge and shall be made at random locations in a specified 8- by 10-foot area, with no reading deviating more than allowed above."

The sunlight specification is as follows:

"Provide variable intensities of simulated solar radiation from 0 to 360 Btu/sq. ft./hr. (0 to 105.5 watts/ft.^{2}) in variable time cycles up to 14 hours maximum consisting of variable time cycles from 5 minutes to 6 hours maximum, without material change in spectral distribution.

"This will require variability of sunlamp elevation (requiring the design, construction, and installation of an elevating mechanism) adjustable from five to ten feet above the floor to the underside of the lamps.

"Increasing intensity shall be accomplished by illuminating the lamps in three steps and then reducing the distance between the lamps and the measuring plane for continuous increase thereafter until the maximum intensity is reached. The measuring plane for maximum intensity shall be no closer than three feet from the underside of the lamps.

"The measuring test plane shall be an 8- by 8-foot area.

"The ranges and percentages of spectral distribution shall be 50 to 60 per cent in the infrared (above 7,600 Angstrom units) and 4.5 to 6 per cent in the ultraviolet (below 3,800 Angstrom units), with the following provisions:

"The average spectral distribution in each range (ultraviolet visible and infrared) in any one plane must fall within the tolerances of 50 to 60 per cent in the infrared (above 7,600 Angstrom units) and 4.5 to 6 per cent in the ultraviolet (below 3,800 Angstrom units). However, variation across any horizontal plane should not exceed plus or minus 10 per cent of the average for that plane.

"This means that every reading of spectral intensity shall fall within the range of ultraviolet or infrared, as mentioned above, except that the contractor shall be permitted to vary beyond the limits of the particular spectral range so long as such variance is within plus or minus 10 per cent of the average reading in the plane considered, which average reading must, however, be within the range of 50 to 60 per cent in the infrared (above 7,600 Angstrom units) and 4.5 to 6 per cent in the ultraviolet (below 3,800 Angstrom units.

"Also, total intensity of simulated solar radiation must not vary more than plus or minus 10 per cent in any horizontal plane over the 8- by 8-foot cross-sectional area served."

"The cost of modern equipment reemphasizes the need for design and selection of materials that can withstand the environmental extremes that will be encountered in worldwide operations."

AFTER analyzing the shortcomings of former methods used to produce laboratory rain and sunshine, it was decided that a radically different approach was necessary to obtain more realistic simulation of both environments. The problems that had to be solved were: Simulation of droplet size which would be within the range of ½ to 6 mm. in diameter, a water source which would ensure uniform coverage of a test plane, and a similar water source which would allow for variations in water output to permit flow rates of from ½-inch to 24 inches per hour on the test plane.

Extensive research and development time was invested to find the best methods of producing the desired results. It was finally determined that a single droplet source, such as a capillary tube, would offer the best reproducibility of all parameters. The inner diameter and the length of the capillary tube ensures close control of water volume flowing from the tube under various pressure heads.

The annular area of the capillary tube presented a constant surface area so that water emitting from the orifice would build up in volume to a droplet of sufficient weight to enable it to overcome surface tension and thus fall into space.

Similarly, the length of the capillary tube represents a finite pressure drop which also must be kept constant in order that uniform distribution be achieved. Variations of water quantity are achieved by varying the water head acting on the capillary tubes to change the flow rate from ½-inch to 24 inches per hour within the tolerances given.

The installation of this capillary system was achieved in the following manner: The proper number of capillary tubes was determined and resulted in a number of tubes well over 11,000 for the area required. These tubes were securely sealed and bonded into the bottom of completely sealed stainless-steel pans which were then mounted on the underside of the ceiling of the environmental chamber.

The chamber itself was built 24 feet high, which was the maximum height available within the building, to permit the droplets as much free fall as possible in order to achieve natural terminal velocity. The water fell on a perforated floor through which it drained to a stainless-steel sump leading to an insulated storage tank. The storage tank was equipped with heating and refrigerating equipment in order to maintain the water at the desired control temperature.

FROM the storage tank the water was lifted by centrifugal pump through pressure-regulating devices to a series of micrometer needle valves. These valves could be set accurately for various flow levels and checked with a variable-diameter flow meter to produce rainfall intensities as required. A combination of these metering devices used in parallel results in the totalization of the individual flow rates of each needle valve.

The water thus metered and controlled is pumped through a series of filters to a standpipe located several feet above the capillary tubes. This standpipe creates the varying liquid head in accordance with rainfall-intensity requirements.

A conditioning system within the room itself moved air in a vertical direction opposite to the waterflow, reducing the possibility of nonuniformity by side-to-side air motion as well as removing mist and water vapor which might otherwise fall. The air used to accomplish this was then passed through the conditioning compartment where heating or cooling could be accomplished.

The investigation of the sunshine simulation problem resulted in the following conclusions: It appeared impossible to achieve the uniform distribution in any plane with the use of more than one type of lamp since there would be areas directly under each of these lamps where the energy that the lamp emitted would be higher than elsewhere.

The only way that uniform distribution could ever be achieved with the combination of lamps would be to have an almost infinite number of small lamp sources which could be mixed in such a manner as to produce negligible stratifications. These facts pointed to the need for developing a single source to produce the entire spectrum as required.

Since the requirement for ultraviolet energy is reasonably high, it became apparent that the source would have to be a lamp which would permit energy output in the visible and infrared range as well as in the ultraviolet range.

The source chosen was a mercury-vapor lamp. One of the shortcomings of this type of lighting device is its inability to vary the output over a large range. Lamps of this type must be operated at nearly full voltage in order to produce their given output, thus offering relatively little flexibility in the amount of intensity to be achieved.

The particular problem which developed was the phenomenon that each lamp produces some energy at virtually every point in the measuring plane. In other words, a lamp located at the upper left-hand corner would produce some energy measurable in the lower right-hand corner. Thus it was necessary to select lamps in banks in such a manner that the overlapping effect which represents the total accumulation of energies at any given point would maintain uniformity. Two such reduced lamp bank levels were obtained. The third step resulted in all lamps having to be energized.

IT further developed that an area completely blanketed with lamps on uniform centers produced points of extremely high intensity across the plane. Such points were particularly evident at or near the center of the measured plane since the center of the room represented the closest distance to all of the lamps in the assembly.

The calculations were employed to determine the high spots which would result and necessitated the removal of approximately 10 per cent of the lamps originally designed into the assembly to produce uniform intensity.

The entire lamp assembly was installed on a rack capable of being raised or lowered from a maximum position of 10 feet above the chamber floor to a minimum position of 3 feet above the chamber floor, thus achieving the variable intensity from zero to 140 watts per square foot.

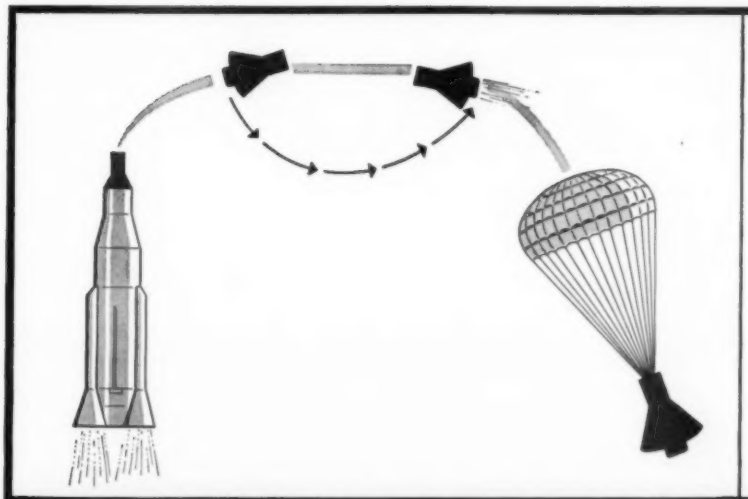
The mechanism designed to raise and lower the lamps was further equipped with program-cycling devices to permit the reproduction of a typical summer day, beginning with sunrise and increasing in intensity to the hour of noon; maintenance of maximum intensity for a variable number of hours; and reduction to zero intensity for sunset in the evening.

A custom-built spectral radiometer was employed to obtain both the total energy generated as well as the actual spectral distribution. Since both the sunlamp as well as the rain-producing equipment covered the entire ceiling area of the test room, it was, of course, necessary to have the sunlamp racks installed in such a manner as to permit easy removal from the test room during rain operation.

THIS arrangement permitted the rapid interchange of sunshine and rainfall tests to make possible the simulation of natural conditions. The sunlamps themselves were connected to the power source by multipin connectors, thus requiring a minimum of interconnecting tie-ins. The air temperature during sunshine tests is maintained by means of the circulating air passing over the sunlamps and thence through cooling coils capable of removing approximately 60 kilowatt-hours of heat generated by this equipment.

This facility at Frankford thus provides what is almost certainly the most advanced rain and sunshine chamber in existence. It gives maximum flexibility in both rainfall and spectral simulation as well as the most nearly accurate simulation of these natural environments ever achieved.

What is perhaps far more important, this facility may prove that sharply varying intensities and levels of these environments can produce detrimental effects not previously recognized. This in turn can establish a new factual basis for needed revisions in relatively loose ordnance specifications which no longer can be considered adequate.



1. NASA flight plans call for ICBM-launching. The manned Mercury capsule will reach orbital velocity at about 120 miles, separate from the missile and ride horizontally in orbit.

2. Hurtling at 18,000 mph, the capsule will circle the earth in 90 minutes. Going into its re-entry phase, the capsule will be rotated by attitude controls to come "home" bottom down.

3. A drogue parachute will be deployed at 70,000 feet, decelerate the capsule and stabilize it. The final descent chute will be deployed at 10,000 feet preparatory for surface landing. Just prior to landing, pneumatic bags stored in the rim of the capsule will inflate to assure stability if landing is in water.

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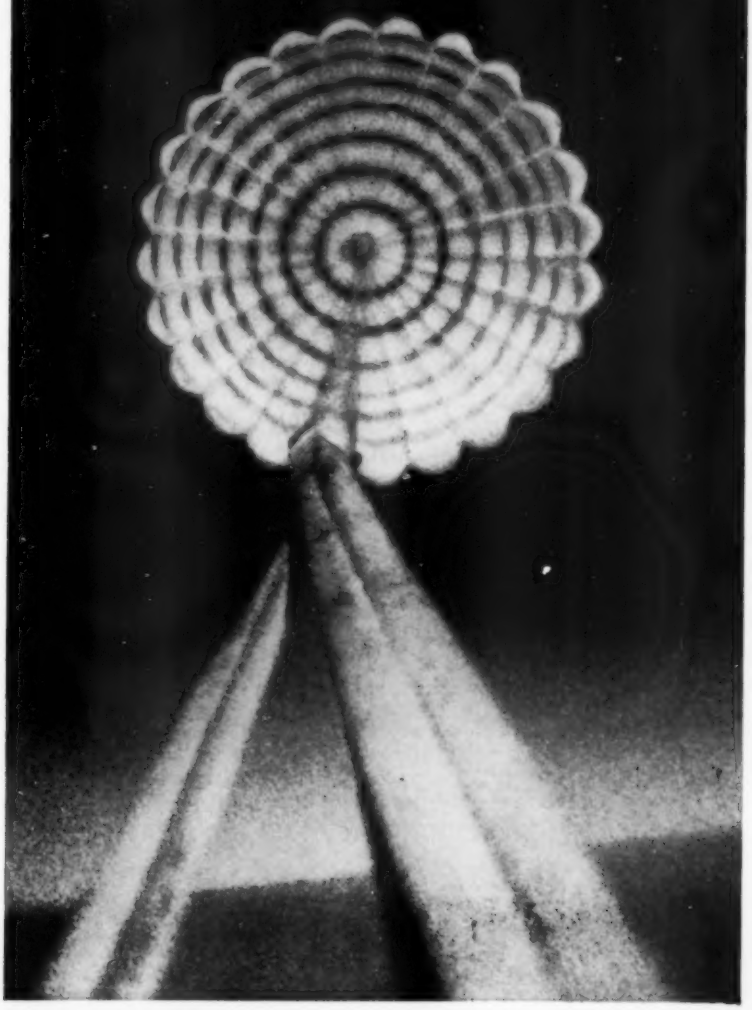

NEW TYPE OF RADIOPLANE PARACHUTE AN INTEGRAL PART OF NASA'S PLAN FOR RECOVERING FIRST MAN IN SPACE

The leader in the development, testing and manufacture of recovery systems – Radioplane–was selected by McDonnell Aircraft Corp. to join the National Aeronautics and Space Administration's Project Mercury.

Today Radioplane is readying the capsule landing system. For the project, Radioplane will use the new Ringsail parachute–a parachute with two radical departures from conventional Ringslot style. For a new kind of performance, Radioplane designed the new crescent-shape-slot parachute. The Ringsail withstands and reduces by as much as 35%, parachute opening shock at high-speed deployment. Drag coefficient and inherent stability are increased.

To solve the problem of aerodynamic heat without loss of strength, Radioplane is presently developing a high-temperature-tolerant fabric for drag devices.

This landing system for Project Mercury exemplifies Radioplane's unique capabilities. Scientists and engineers in Radioplane's Paradynamics Group combine their experience in the recovery field with the newest in equipment to develop systems with the highest degree of reliability. They are continually solving the increasingly complex recovery problems of the space age – producing the most efficient answers – at minimum cost.

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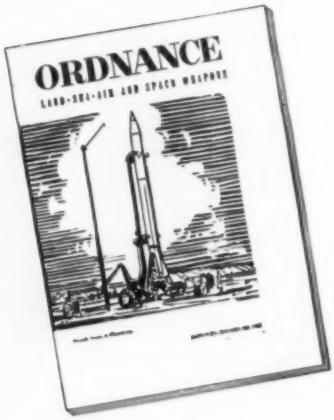

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Index of Advertisements

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	Page
ACF Industries, Incorporated, American Car and Foundry Division	367
Aerojet-General Corporation	363
Aeronca Manufacturing Corporation	377
Aetna-Standard, A Division of Blaw-Knox Company	458
Aircraft Armaments, Inc.	476
Aluminum Company of America	459
American Cystoscope Makers, Inc.	462
American Machine & Foundry Company, Government Products Group	348
Ampex Corporation, Professional Products Division	429
Arma Division, American Bosch Arma Corporation	487
Austin-Western Division, Baldwin-Lima-Hamilton Corporation	427
Avco Corporation	463
Nashville Division	471
Bell Telephone Laboratories, Inc.	435
Bendix Aviation Corporation, Scintilla Division	376
Borg-Warner Corporation	447
Bulova Watch Company	431
Bundy Tubing Company	355
Burroughs Corporation	371
Carlstrom Pressed Metal Company	490
Caterpillar Tractor Co.	456
Chance Vought Aircraft, Inc.	440
Cleveland Container Company	452
Commerce Clearing House, Inc.	430
Consolidated Electrodynamics Corporation	349
Continental Motors Corporation	374
Detroit Diesel Engine Division, GMC	498
Dewey & Company, G. C.	438
Douglas Aircraft Company	437
Dow Chemical Company	483
Emhart Manufacturing Company	428
Flynn Manufacturing Company, Michael	466
Fuller Brush Company	496
Garrett Corporation	354, 426, 468
General Dynamics Corporation	491
General Electric Company	484
Light Military Electronic Equipment Department	481
General Mills, Inc.	356
Graphic Systems	464
Gurley, W. and L. E.	442
Hallicrafters Company	366
Hamilton Standard Division, United Aircraft Corporation	495
Hercules Powder Company	465
Hoffman Laboratories, Division of Hoffman Electronics Corporation	365
Hunter Manufacturing Company	470
International Business Machines Corporation	Cover IV
International Nickel Company	372
Janitrol Aircraft Division, Surface Combustion Corporation	486
Kaiser Aluminum & Chemical Sales, Inc.	439
Kearfott Company	362
Keuffel & Esser Company	496
Kollmorgen Optical Corporation	359
Librascope, Inc	361
Lockheed Aircraft Corporation	432
Luria Engineering Company	360
Magnavox Company	480
Markem Machine Company	482
Martin Company	478
Mason & Hanger-Silas Mason Company	376
McCormick Selph Associates	375
Mitchell Camera Corporation	368
Motorola, Inc., Military Electronics Division	443, 444
National Tube Division, U. S. Steel Corporation	436
Niagara Blower Company	462
Northern Ordnance, Incorporated	464
Northwestern Ordnance Parts Division, NAPCO Industries, Inc.	358
Oakite Products, Inc.	364
Ordnance Research & Development Company	370
Pan American World Airways, Inc.	518
Parsons Company, Ralph M.	Cover III
Philco Corporation	497
Radio Corporation of America	453, 493
Radioplane, A Division of Northrop Corporation	515
Raytheon Company	352
St. Louis Car Company	378
Singer Manufacturing Company, Military Products Division	500
Sorensen & Company	446
Sperry Phoenix Company, Division of Sperry Rand Corporation	369
Stackpole Company	490
Stanpat Company	474
Stavid Engineering, Inc.	472
Structural Fibers, Inc.	460
Sylvania Electric Products, Inc.	477
Technical Development Company	454
Texas Instruments, Inc.	373, 494
Thiokol Chemical Corporation	455
Thompson Ramo Wooldridge Inc., Tapco Group	379
Timken Roller Bearing Company	Cover II
Twin Lock Incorporated	469
Washington Technological Associates	350
Western Gear Corporation	461
Westinghouse Electric Corporation	488
Willys Motors, Inc.	351

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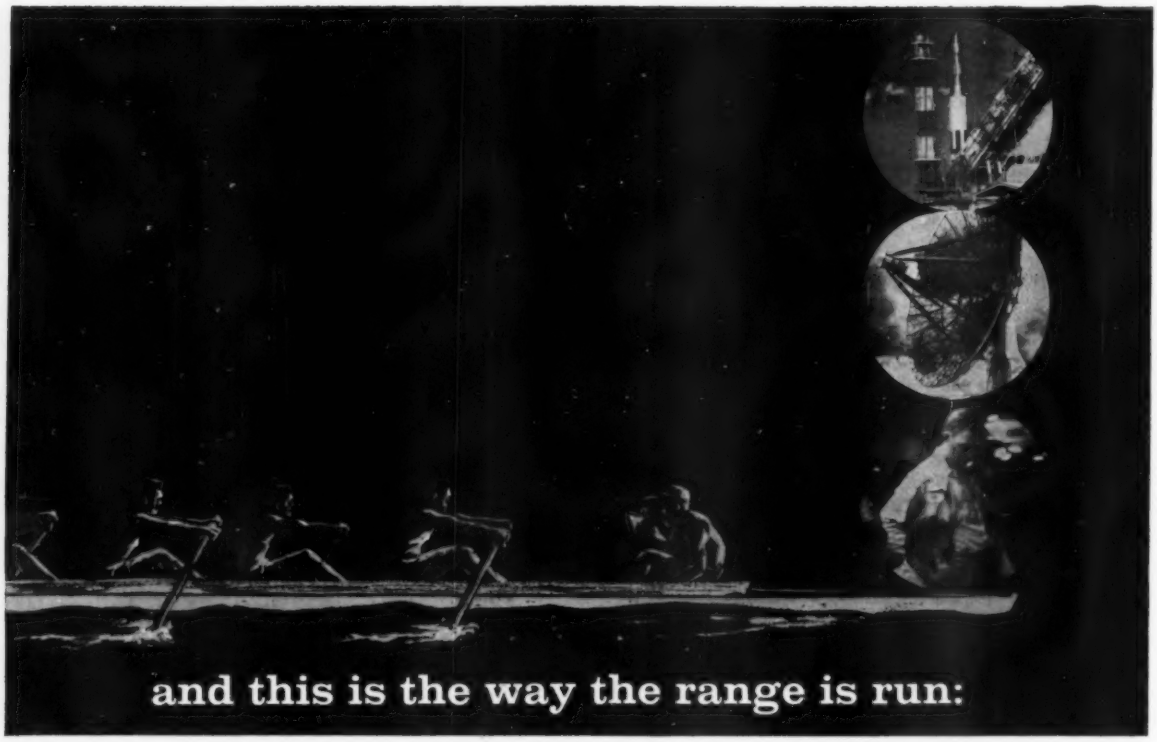

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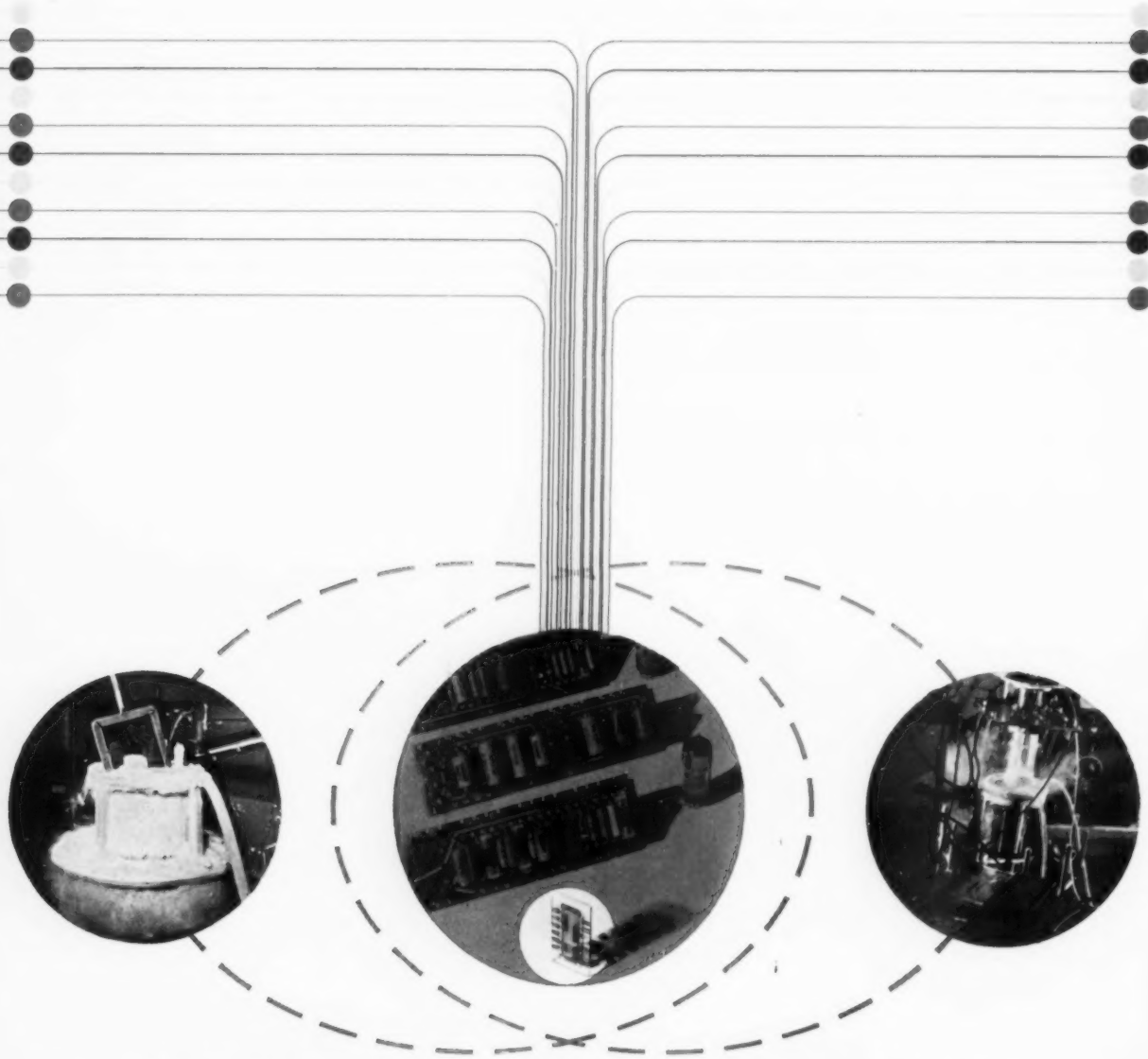

In center, conventional circuitry is contrasted with equivalent cryogenic device (in white circle). Left and right photos show details of specially designed apparatus used to achieve low temperatures for superconductivity.